IMPERIAL MYCOLOGICAL
29 OCT 1942
INSTITUTE

THE

Tea Research Institute

OF

Ceylon.

BULLETIN No. 23

Annual Report for the Year 1941.

Published by
THE TEA RESEARCH INSTITUTE OF CEYLON,
ST. COOMBS, TALAWAKELLE.

The Tea Research Institute of Ceylon.

SCIENTIFIC STAFF.

Director ... Roland V. Norris, D.Sc. (Lond.), M.Sc. (Manc.), F.I.C.

Department of Mycology.

Mycologist	...	C. H. Gadd, D.Sc. (Birm.)
Assistant Mycologist	...	T. E. T. Bond, Ph.D. (Cantab), M.Sc. (Reading).
Assistant	...	C. A. Loos.

Department of Agricultural Chemistry.

Agricultural Chemist	...	T. Eden, D.Sc. (Manc.), A.I.C.
Research Assistant	...	J. G. Shrikhande, Ph.D. (Lond.) M.Sc. (Nagpur), A.I.C.
Assistant	...	E. N. Perera
Field Assistants	...	M. Piyasena
	...	F. P. Jayawardana

Department of Biochemistry.

Biochemist	...	J. Lamb, M.Sc. (Lond.) A.I.C., A.I.C.T.A [on military duty]
Research Assistant	...	H. B. Sreerangachar, M.Sc. (Bombay), B.Sc. (Mysore), A.I.C., A.I.I.Sc.
Assistants	...	V. Mendis
	...	E. L. Keegel
	...	P. R. Perera

Department of Entomology.

Entomologist	...	C. B. Redman King, M.A. (Cantab.), M.C.
Assistant Entomologist	...	G. D. Austin [on military duty]
Assistant	...	D. J. William
Field Assistant	...	W. T. Fonseka

Department of Plant Physiology.

Plant Physiologist	...	F. R. Tubbs, Ph.D. (Lond.), D.I.C., A.R.C.S., F.L.S. [on military duty]
Voluntary Worker	...	Mrs. T. E. T. Bond, M.Sc. (Reading)
Assistant	...	M. H. E. Koch
Field Assistants	...	F. H. Kehl

Small-Holdings Officers.

	...	R. L. Illankoon [on military duty]
	...	F. D. Tillekeratne

Superintendent, St. Coombs Estate ... J. A. Rogers

NOTE.

The Laboratories of the Institute are situated at St. Coombs Estate, Talawakelle, and letters and enquiries should be addressed to the Director, Tea Research Institute of Ceylon, St. Coombs, Talawakelle. Telegraphic Address:—Research, Talawakelle; Telephone, Talawakelle 44 (Private Exchange). It is particularly requested that letters should not be addressed to officers by name.

SIXTEENTH ANNUAL REPORT

OF THE

BOARD OF THE TEA RESEARCH INSTITUTE OF CEYLON

FOR 1941.

Foundation.—The Tea Research Institute was established by Ordinance No. 12 of 1925, dated the 27th October, 1925. The Constitution of the Board is laid down in that Ordinance; the personnel on the 1st day of January, 1941, was:—

Ex-Officio Members.

The Hon'ble the Financial Secretary (Hon'ble Mr. H. J. Huxham).
The Director of Agriculture (Mr. E. Rodrigo, C.C.S.)
The Chairman, Planters' Association of Ceylon (Mr. R. C. Scott).
The Chairman, Ceylon Estates Proprietary Association (Mr. C. H. Bois).

Representatives of the Planters' Association of Ceylon.

Mr. James Forbes (on leave) Mr. G. K. Newton (Acting).
Mr. R. G. Coombe.
Mr. J. D. Hoare.

Representatives of the Ceylon Estates Proprietary Association

Major J. W. Oldfield, C.M.G., O.B.E., M.C.
Mr. I. L. Cameron (on leave) Mr. W. H. Gourlay (Acting).
Mr. J. C. Kelly.

Representative of the Low-Country Products Association

Mr. S. F. H. Perera.

Representative of the Small-Holders

Mr. T. B. Panabokke, First Adigar (Chairman).

Chairman.—Mr. T. B. Panabokke, First Adigar.
Secretary.—Dr. Roland V. Norris.
Solicitors.—Messrs. Julius & Creasy.
Auditors.—Messrs. Ford, Rhodes, Thornton & Co.
Registered Office.—The Victoria Commemoration Building, Kandy.

Mr. R. C. Scott ceased to be a Member of the Board on the 21st March, 1941, on vacating the Chair of the Planters' Association and was succeeded by Mr. D. E. Hamilton, the new Chairman of the Association.

Mr. S. F. H. Perera's term of office expired on the 24th September, 1941, and Mr. W. P. H. Dias was nominated by the Low-Country Products Association as their representative for a term of three years as from 17th November, 1941.

Cordial thanks are due to Mr. Scott and Mr. Perera for the great interest they took in the affairs of the Institute during their term of office on the Board.

Four meetings of the Board were held during the year, the average attendance being nine.

COMMITTEES.

Finance Sub-Committee.—The Chairman, T. R. I.; the Chairman, Planters' Association of Ceylon; the Chairman, Ceylon Estates Proprietary Association; Major J. W. Oldfield, C.M.G., O.B.E., M.C.; Mr. J. D, Hoare, Mr. J. C. Kelly and the Director, T. R. I.

This Committee held two meetings during the year.

Estate and Experimental Sub-Committee.—The Director, T. R. I. (Chairman); the Chairman, T. R. I.; the Visiting Agent (Mr. H. Tonks); the Superintendent, St. Coombs; Messrs. R. G. Coombe, D. T. Richards R. H. Horne, W. J. Craig, F. J. Whitehead, G. K. Newton and Dr. T. Eden (Secretary).

During Dr. Eden's absence on six months' leave, the Director acted as Secretary of the Committee which held three meetings during the year.

Medical Scheme Sub-Committee.—The Chairman, T.R.I.; the Director, T.R.I.; and Mr. G. D. Austin (representing the Junior Staff).

Trustees of the Junior Staff Provident Fund.—The Chairman, T.R.I.; the Director, T.R.I.; Mr. R. G. Coombe and Mr. E. N. Perera (representing the Junior Staff).

Visiting Agent.—Mr. H. Tonks continued to act as Visiting Agent and paid three visits of inspection to St. Coombs during the year. The thanks of the Board are due to him for his valuable advice.

FINANCE.

The year was a favourable one, chiefly due to the increased profit on St. Coombs Estate.

The total receipts amounted to Rs. 418,311, made up as follows:— Cess Rs. 322,190, Profit on St. Coombs Estate Working Account Rs. 79,966 and Interest and Miscellaneous Receipts Rs. 6,155. Receipts were thus Rs. 22,699 higher than in 1940.

Expenditure on Revenue Account, including Research Revenue Expenditure at Rs. 234,529, Depreciation at Rs. 39,799 and Interest Charges on the Government Loan, amounted to Rs. 311,578 as against Rs. 315,627 in 1940. There was thus a surplus on Revenue Account of Rs. 106,733, the corresponding figure for 1940 being Rs. 79,814.

Capital Expenditure was incurred to the extent of Rs. 87,043, this sum comprising expenditure on assets of Rs. 49,494 and Rs. 37,549 representing repayment of the Government Loan. The chief item of expenditure on assets was in connection with the improvement to St. Coombs Factory.

Liquid assets as at 31st December, 1941, after providing for specific liabilities such as accrued interest on the Government Loan and Furlough and Passages Reserve amounted to Rs. 341,922. The liability under the Depreciation Reserve at the same date was Rs. 438,836.

ST. COOMBS ESTATE.

Excessive rain in May caused some damage on the estate, but thereafter weather conditions were favourable for crop. The latter amounted to 203,573 pounds, or 771 pounds per acre, against an estimate of 185,000 pounds.

116,547 pounds of made tea were supplied to the Ministry of Food and realised 81.88 cents per pound nett. 86,362 pounds were sold on the Colombo market realising Rs. 1.21 per pound nett.

The average price obtained for the whole crop was Rs. 1/01.7 gross and cents 98.27 nett per pound.

With cost of production at 59.34 cents, the profit on Working Account amounted to Rs. 79,966 or Rs. 302 per acre.

PUBLICATIONS.

The following publications were issued during the year:—

The Tea Quarterly, Vol. XIV, Parts I-IV.
Bulletin No. 22, Annual Report for 1940.

Subscriptions for publications from those not entitled to a free issue amounted to Rs. 3,781 and receipts from advertisements brought in Rs. 2,792.

ACKNOWLEDGMENTS.

As usual close co-operation has been maintained with the Ceylon Association in London, the Planters' Association of Ceylon, the Ceylon Estates Proprietary Association, and other bodies concerned in the Tea Industry and the thanks of the Board are due to these Associations for their continued interest and assistance in the working of the Institute.

Thanks are due to the Ceylon Chamber of Commerce, Colombo, for the use of their Committee Room for meetings of the Board held in Colombo

The Audited Statement of Accounts and Balance Sheet for 1941 are attached, together with the reports of the Visiting Agent and of the Director and Scientific Staff dealing with the research activities of the Institute.

ROLAND V. NORRIS,
Secretary

THE TEA RESEARCH INSTITUTE OF CEYLON

BALANCE SHEET AS AT 31st DECEMBER, 1941.

LIABILITIES		Rs. Cts.	Rs. Cts.
CREDITORS & CREDIT BALANCES :—			
Accrued Interest on Loan	...	8,925·27	
Sundry Creditors—Research	...	6,693·96	
Sundry Creditors—Estate	...	22,568·87	
Subscriptions for Publications received in advance	...	88·56	38,276.66
FURLOUGH RESERVE :—			
At 31st December, 1940	...	6,205·18	
Additions during 1941	...	9,991·35	
		16,196·53	
Deduct : Payments during 1941	...	4,902·83	11,293·70
DEPRECIATION RESERVE :—			
At 31st December, 1940	...	399,361·99	
Credited at 31st December, 1941	...	39,798·94	
		439,160·93	
Less : Items written off in 1941	...	325·00	438,835 93
Carried over			Rs. 488,406·29

ASSETS		Rs. Cts.	Rs. Cts.
DEBTORS & DEBIT BALANCES :—			
Principal Collector of Customs (since received)	...	27,172·03	
Interest on £2,300, 3½% War Loan £40 5·0	...	531·14	
Mr. Parfitt House Rent etc.	Rs. 118·29		
Labour	,, 16·66		
Nutbourne Estate sale of Tea Stumps	,, 30·00		
Lindoola Estate, Upkeep of Mattakelle Cart Road	,, 250·00	414·95	
Davidson & Co., Ltd. Allowance on Induced Fan and Pulley		325·00	28,443·12
SUNDRIES—RESEARCH :—			
Ceylon Association in London £17 8·5	Rs. Cts. 232·27		
Research Staff	1,935·54		
Sundry Debtors A/c. Advertising	... 866·00		
Suspense A/c. Mr. Parfitt	... 3·07		
Accrued Interest on Fixed Deposits	... 1,430·08		
	4,466·96		
SUNDRIES—ESTATE	... 2,764·47		7,231·43
STOCKS-IN-HAND:—			
Tea 34,546 lbs.	...	37,302·12	
Estate Rice	...	1,303·20	
Stock A/c.	...	11,568·80	50,174·12
Carried over			Rs. 85,848·67

THE TEA RESEARCH INSTITUTE OF CEYLON

BALANCE SHEET AS AT 31st DECEMBER, 1941.—(*Contd.*)

LIABILITIES	Rs. Cts.	ASSETS	Rs. Cts.	Rs. Cts.
Brought forward	Rs. 488,406·29	Brought forward		Rs. 85,848·67
		INVESTMENTS :—		
		£ 2300 0·0, 3½% War Loan ...		32,434·76
		Rs. 50,000/- 2½% Ceylon Govt. Loan ...		50,000·00
		Rs. 30,000/- 3½% do 1957/62 ...		29,512·50
		£2,063·18· 1. 4% Funding Loan 1960/90		29,928·06
		Rs. 50,000/- 2½% Ceylon Govt. Loan 1948		50,000·00
		CASH :—		
		Fixed Deposit ...	61,015·00	
		Current Account ...	44,654·74	
		Petty Cash A/c. ...	605·82	
			106,275·56	
		Estate—N.B.I. Colombo Rs. 9,496·28		
		,, In hand ,, 27·25	9,523·53	115,799·09
		FUNDS OVERSPENT		
		TO 31st December, 1940 ...	114,572·71	
		Capital Expenditure 1941 ...	49,493·62	
		Repayment of Govt. Loan 1941 ...	37,549·44	
			201,615·77	
		Less : Revenue applied for Capital purposes, being Revenue Account Surplus for the year 1941	106,732·56	94,883·21
	Rs. 488,406·29			Rs. 488,406·29

We have audited the books of the Tea Research Institute of Ceylon and have obtained all the information and explanations required by us.

The allocations of Capital Expenditure and of Research Revenue Expenditure as made by the Director have been accepted by us.

We are not in a position to say whether the Reserves made for Depreciation are adequate.

Subject to the foregoing reservations, the above Balance Sheet, in our opinion, is properly drawn up so as to exhibit a true and correct view of the financial affairs of the Institute at 31st December, 1941, according to the best of our information and the explanations given to us, and as shown by the books.

(Sgd.) FORD, RHODES, THORNTON & CO.
Chartered Accountants

THE TEA RESEARCH INSTITUTE OF CEYLON

Dr. **CAPITAL ACCOUNT AS AT 31st DECEMBER, 1941.** **Cr**

EXPENDITURE

	To 31-12-40	Additions in 1941	Transferred from Capital A/c.	Deduct cost of Assets sold or scrapped in 1941	Total
	Rs. Cts.	Rs. Cts.	Rs. Cts.	Rs. Cts.	Rs. Cts.
To Land, Including Development	851,816·25	15.968·37	—	—	867,784·62
,, Buildings and Lines	913,495·82	29,285·61	90·00	—	942,691·43
,, Furniture and Equipment	81,037·45	1,200·44	313·07	—	81,924·82
,, Laboratory and Equipment	42,621·18	2·20	—	—	42,623·38
,, Experimental Machinery	29,705·38	—	—	—	29,705·38
,, Machinery—Estate	128,344·37	3,687.00	—	650·00	131,381·37
,, Motor Road Roller	7,386·03	—	—	—	7,386·03
,, Motor Car	4,025·00	—	—	—	4,025·00
	Rs. 2,058.431·48	50,143·62	403·07	650·00	2,107,522·03

St. Coombs,
24th March, 1942

RECEIPTS

	Rs. Cs.	Rs. Cts
By Government of Ceylon:— Loan on Mortgage at 5½% per annum	1,000,000·00	
Less: Repayments to 31-12-41	350,889·58	649,110·42
,, Revenue Applied for Capital Purposes to 31-12-41	1,257,198·91	
do do 1941	106.732·56	
	1,363,931·47	
Less: Transfers between Capital and Revenue	403·07	1,363,528·40
,, Funds Overspent to 31-12-40	114,572·71	
Less: 1941 Underspent	19,689·50	94,883·21
		Rs. 2,107,522·03

(Sgd.) ROLAND V. NORRIS
Director.

THE TEA RESEARCH INSTITUTE OF CEYLON

LOAN ACCOUNT

Dr.			Cr.
			Rs Cts.
To Government of Ceylon	Rs. 1,000,000·00	By Repayments Principal to 31-12-40	313,340·14
		,, Do 1941	37,549·44
		,, Balance	649,110·42
	Rs. 1,000,000·00		Rs. 1,000,000·00

St. Coombs,
24th March, 1942

(Sgd.) ROLAND V. NORRIS.
Director.

THE TEA RESEARCH INSTITUTE OF CEYLON

ESTATE WORKING ACCOUNT AS AT 31st DECEMBER, 1941

EXPENDITURE	Rs. Cts.	Rs. Cts.	INCOME		Rs. Cts.
To Estate Expenditure Revenue Previously ...	108,220·87		By Tea Sales—Colombo ...	86,362 lbs.	108,899·98
,, do do December	12,583·31	120,804·18	,, do Tea Commissioner ...	116,547 ,,	97,381·42
,, Charges—Export Duty, Etc. ...	...	6,710·85	,, do Local ...	504 ,,	329·92
,, Balance Carried Forward ...	...	79,965·59	,, do Broken Mixed ...	3,111 ,,	466·65
			,, do Biochemical Dept. ...	160 ,,	156·80
			,, Motor Road Roller Account		245·85
		Rs. 207,480·62			Rs. 207,480·62

1940				1941			
December Rainfall	3·24 ins.	No. of rainy days	16	December Rainfall	2·67 ins.	No. of rainy days	13
Total do	88·57 ins.	do	221	Total do	110·72 ins.	do	236

REVENUE ACCOUNT AS AT 31st DECEMBER, 1941

Dr.	Rs. Cts.	Rs. Cts.	Cr.	Rs. Cts.
To Administration of the Board :—				
Planters' Association of Ceylon ...	240·00		By Tea Cess Collections ...	332,189·97
Travelling of the Board ...	1,540·10		,, Rent of Caddy ...	60·00
Clerical Staff ...	6,300·00		,, Interest ...	5,948·12
Telephone Operators ...	1,005·00		,, Miscellaneous Receipts ...	112·00
Office Peon ...	630 00		,, Guest House Account ...	35·34
Postages ...	408·62		,, Balance from Estate Working Account	79,965·59
Stationery ...	1,083·30			
Advertising ...	13·44			
Telegrams, Trunk Calls, etc. ...	197·75			
Printing ...	50·00			
Legal Expenses ...	31·50			
Auditors' Fees ...	752·13			
Contingencies ...	147·59	12,399 43		
Carried over		Rs. 12,399·43	Carried over	Rs. 418,311·02

THE TEA RESEARCH INSTITUTE OF CEYLON

Dr. **REVENUE ACCOUNT AS AT 31st DECEMBER, 1941.**—*(Contd.)* **Cr.**

		Rs. Cts.	Rs. Cts.
	Brought forward		12,399·43
To Personal Emoluments of Scientific Staff :—			
Director	...	22,500·00	
Mycologist	...	20,250·00	
Agricultural Chemist	...	18,750·00	
Entomologist	...	12,722·78	
Plant Physiologist	...	7,434·98	
Biochemist	...	13,130·36	
Asst. Mycologist	...	9,537·50	104,325·62
„ Emoluments—Junior and Sub-Scientific Staff :—			
Junior Scientific Staff	...	40,081·06	
Labour Attendants and Fieldman		4,896·24	44,977·30
„ Laboratory :—			
Equipment and General Working Expenses	...	3,785·48	
Special Provision for Joint Research on Chemistry of Tea	...	5,029·34	
Furniture and Office Equipment		85·82	8,900·64
„ Library and Publications :—			
Library	...	1,656·37	
Publications	...	Cr. 2,314·66	Cr. 658·29
	Carried over	Rs.	169,944·70

	Rs. Cts.
Brought forward	Rs. 418,311·02
Carried over	Rs. 418,311·02

Dr. **REVENUE ACCOUNT AS AT 31st DECEMBER, 1941.**—*(Contd.)* **Cr.**

	Rs. Cts.	Rs. Cts.
Brought forward		169,944·70
To Field and Factory Experiments :—		
Agricultural Chemist ...	2,997·56	
Plant Physiologist ...	714·25	
Miscellaneous Field Experiments	125·70	
Factory Experiments ...	2,463·58	6,301·09
„ Small-Holdings :—		
Salaries and House Allowances ...	5,727·83	
Travelling and General Expenditure ...	3,085·87	8,813·70
„ Travelling of Staff :—		
Officers' Expenses ...	1,219·44	
Insurance of Car and Licence ...	150·72	
Drivers' Wages ...	1,329·00	
Drivers' Batta ...	261·75	
Running Expenses ...	1,815·30	4,776·21
„ Maintenance of Buildings :—		
Laboratory ...	150·64	
Six Senior Staff Bungalows ...	1,165·49	
Junior Staff Bungalows (13) ...	1,044·41	
Clerks' Bungalows (3) ...	398·15	
Miscellaneous Lines and Buildings	716·14	
Passara Buildings ...	15·25	
Guest House ...	96·49	3,586·57
Carried over Rs.		193,422·27

	Rs. Cts.
Brought forward	418,311·02
Carried over Rs.	418,311·02

THE TEA RESEARCH INSTITUTE OF CEYLON

Dr. **REVENUE ACCOUNT AS AT 31st DECEMBER, 1941.—(*Contd.*)** **Cr.**

		Rs. Cts.	Rs. Cts.
	Brought forward		193,422·27
To General Services :—			
Electric Power	...	5,225·75	
Mechanic	...	901·61	
Telephone Rent and Maintenance		623·69	
Roads	...	375·00	
Sanitation	...	873·66	
Water Supply	...	2,473·32	
Tappal Lorry and Book Fees	...	264·00	
Nettikans and Drains	...	198·24	
Upkeep of Grounds	...	593·77	
Guest House	...	563·65	12,092·69
,, Miscellaneous :—			
Incidentals	...	251·16	
Ceylon Planters' Provident Society		11,771·79	
Provident Fund, Junior Sc. Staff		4,764 27	
Provident Fund, Sub-Staff	...	1,444·39	
Passages	...	6,000·00	
Ceylon Nursing Assn. and Fraser Nursing Home	...	165·00	
Medical Fees, Sub-Staff	...	192·15	
Medical Scheme Junior Staff	...	1,245·00	
Insurances	...	2,750·18	
Caretakers and Watchmen	...	371·63	
Rentals	...	59·07	29,014·64
,, Government of Ceylon Loan Interest Account	...		37,249·92
,, Depreciation	...		39,798·94
,, Balance	...		106,732·56
			Rs. 418,311·02

Brought forward	Rs. 418,311·02
	Rs. 418,311·02

St. Coombs,
24th March, 1942

(Sgd.) Roland V. Norris.
Director.

REPORT

ON

ST. COOMBS ESTATE

FOR 1941.

The following short report is written on the working of St. Coombs Estate for 1941, specially for inclusion in the Tea Research Institute's Annual Report for 1941, and it is in addition to the usual Visiting Agent's reports on this property.

Superintendent.—Mr. J. A. Rogers.

ACREAGE.

	A.	R	P.
Tea in Bearing	264	1	06
Tea—New Clearing 1937	20	0	00
Tea—New Clearing 1938	16	0	00
Nurseries	1	1	08
Fuel Clearings	33	0	00
Reserve available for planting ...	27	1	09
Building Sites	26	2	22
Waste Land, Swamps, etc. ...	26	1	14
Total ...	414	3	19

Weather.—Rainfall registered in 1941—113.96 inches on 269 days.
Rainfall registered in 1940— 93.84 inches on 247 days.

There was the usual drought in the first quarter of 1941, but it was not so severely felt as during the two previous seasons.

The South West Monsoon came in with unusual violence, and 8½ inches of rain fell on 23rd May, resulting in damage to roads, bridges, nurseries, etc.

This Monsoon was a severe and prolonged one, with constant rain and little sunshine, and it continued into October which is exceptional. The North East Monsoon during the last quarter of 1941 was a normal one.

In spite of the heavy and protracted South West Monsoon, the climatic conditions generally appeared to react favourably on crop.

Crop.—Total crop harvested in 1941—203,573 lbs.—Estimated 185,000 lbs.
Total crop harvested in 1940—175,270 lbs.—Estimated 185,000 lbs.

Crop came in satisfactorily practically throughout the year, resulting in another record crop for St. Coombs, exceeding the previous record in 1940 by 28,303 lbs.

Yield Per Acre.—1941—771 lbs. per acre.
1940—664 lbs. per acre.

The previous record yield per acre, on the 264 acres now in bearing, was exceeded by **107** lbs. per acre.

Prices.—(Sales—exclusive of Broken Mixed).

	Gross Average per lb.	Nett Average per lb.
1941—203,573 lbs.	Rs. 1/01.7	Cts. 98.27
1940—174,388 lbs.	Cts. 87.62	Cts. 85.41

116,547 lbs. were sold to the Minister for Food, London, and realised 81.88 cents per lb. nett.
86,362 lbs. were sold on the Colombo Market, and realised Rs. 1.21 per lb. nett.
664 lbs. were disposed of on the estate.

Total ... 203,573 lbs.

Profit on Estate Working Account.

1941—Rs. 79,966 00, equivalent to Rs. 302.00 per acre.
1940—Rs. 46,507.00, equivalent to Rs. 176.00 per acre.

This excellent profit has been achieved owing to a record crop, and very high prices obtained for teas sold on the Colombo Market.

Cost of Production (Revenue Account).

1941—59.34 cents per lb.—Estimate—64.34 cents per lb.
1940—59.37 cents per lb.—Estimate—58.30 cents per lb.

It has been possible to produce at the same cost as in 1940, in spite of increased wages and high cost of materials, etc. owing to the heavy increase in crop for 1941.

It should be noted that "Proportion of General Charges" amount to 18.34 cents per lb., this is a very high figure as compared with ordinary estate costs, owing to the unique circumstances of St. Coombs Estate.

Normally "General Charges" would probably show a reduction of 8 cents per lb., on this figure, which would bring the cost of production on St. Coombs for 1941 to 51.34 cents per lb., and this figure would, I consider, compare favourably with costs of estates generally in Up-country districts.

Capital Expenditure.

1941—Rs. 47,932.00, or 23.54 cents per lb.—Estimate Rs. 48,987.00, or 26.48 cents per lb.

1940—Rs. 16,283,00, or 9.29 cents per lb.—Estimate Rs. 23,849.00, or 12.89 cents per lb.

1941—Total Cost of Production (Revenue and Capital) 82.88 cents per lb. Estimate—90.71 cents per lb.

Cultivation.—The manuring and other cultivation programmes for 1941 were duly completed. Nitrogen at the rate of an average of 50 lbs., per acre per annum is applied, (except for No. 1 Field, which is on a 2-year pruning cycle, and receives an average of 45 lbs. nitrogen per annum).

Pruning.—Fields are being gradually brought on to a 4 year cycle. The programme was finished, and improvement in the growth of new wood, and increase in the spread of the bushes continue, to be noticeable.

Green Manuring.—Dadaps have been cut out in all fields (except Nos. 1 and 4), and albizzias are being planted.

The supply of green material is considerably augmented by the luxuriant growth of wild sunflower in ravines, etc.

Weeding—has been extremely troublesome on St. Coombs in 1941, and this appears to have been the case on many estates throughout the planting districts.

New Clearings.—1937—20 acres.
1938—16 acres.

These clearings are making steady but slow progress.

11,500 stumps were put out to supply vacancies and sickly plants during the South West Monsoon, and casualties are not expected to be heavy.

Difficulty in establishing bush type green manures continues.

Labour.—At the end of 1941 there were 375 working labourers on the estate, which is equivalent to 1.39 labourers per acre in production.

There has been very little movement during 1941, and the labour force is settled.

Lines.—There are 148 line rooms up to Government Standard, including 12 new rooms (with separate kitchens) built during 1940 and 1941.

Waterborne Latrines.—4 compartments have been newly built, and 10 compartments have been converted during the year under review.

Factory and Machinery.—On Capital Account — Alterations and extensions have been undertaken, consisting of the re-erection of the E.C.P. drier on the same side of the drying room as the Empire drier, with the stoves of both machines in an outside extension, isolated from the main building, and connected to one newly built masonry chimney.

These extensions and alterations have been excellently carried out, and result in a vast improvement.

General.—The year 1941 has been a most successful one, resulting in a record profit, due to a record crop, and high prices for teas sold on the Colombo Market.

These results have been achieved largely owing to Mr. Rogers' hard and conscientious work for many years, as well as to the thoroughly sound cultivation and manuring policy, to which this estate, has consistently adhered.

The general improvement in this property during the last few years is very marked, and the excellent results for 1941 are decidedly encouraging.

HUBERT TONKS,
Visiting Agent

METEOROLOGICAL OBSERVATIONS, 1941.

ST. COOMBS.

MONTH	TEMPERATURES							RAINFALL		RAIN DAYS		SUNSHINE			
	Mean Maximum	Difference from average 1931-1940	Mean Minimum	Difference from average 1931-1940	Adopted Mean	Mean on grass	Mean Relative humidity	Inches	Difference from average 1931-1940	Days	Difference from average 1931-1940	Hours.	Mins.	Difference from average 1931-1940 Hrs.	Mins.
January	75·2	+ 1·5	55·5	- 0·3	65·4	51·4	74	1·91	- 2·21	7	- 4	203	47	+ 8	47
February	77·9	+ 1·8	54·6	+ 0·2	66·2	50·1	68	1·68	- 1·22	9	+ 1	221	21	- 9	10
March	79·5	+ 2·3	54·6	- 0·7	67·0	49·7	67	5·62	+ 1·38	11	- 1	246	27	+ 11	59
April	79·3	+ 2·0	59·1	+ 1 3	69·2	58·0	80	9·68	+ 3·38	17	+ 1	190	03	- 14	11
May	—*	—	60·3	+ 0·4	—	59·4	—	27·36	+14·98	26	+ 7	139	11	- 19	25
June	71·2	+ 0·4	60·8	+ 0·4	66·0	60·3	88	10·22	- 2·19	25	- 2	109	54	+ 15	37
July	71·9	+ 2·1	58·7	- 0·8	65·3	57·8	84	8·57	- 4·10	24	- 2	153	08	+ 45	00
August	70·2	- 0·8	60·8	+ 1·8	65·5	60·8	88	13·38	+ 3·69	31	+ 6	93	26	- 26	44
September	73·3	+ 1·1	59·4	+ 1·3	66·4	58·4	84	7·89	- 0·59	21	0	119	14	- 27	41
October	75·5	+ 2·3	60 0	+ 2·3	67·8	58·5	84	11·84	+ 2·61	24	+ 2	148	18	- 10	02
November	74·4	+ 1·2	60·8	+ 3·4	67·6	58·1	80	9·90	+ 1·73	28	+ 8	94	02	- 60	14
December	74·5	+ 0·8	55·0	- 1·2	64·8	51·1	78	2·67	- 2·26	13	- 2	159	12	- 26	34
Annual	—	—	58·3	+ 0·68	—	56·1	80	110·72	+ 15·20	236	+ 14	1878	03	- 112	38
	Means							Totals							

* Thermometer out of order

REPORT

OF

THE DIRECTOR,

TEA RESEARCH INSTITUTE OF CEYLON

FOR 1941.

Finance.—The year was a favourable one owing to increased profits from St. Coombs Estate due to a larger crop and high tea prices prevailing on the Colombo Market. Details of receipts and expenditure will be found in the Report of the Board and the Institute's Accounts published earlier in this Report.

The Board had under consideration during the year the question of the Institute's cash reserves. In view of the very uncertain position caused by the war and the impossibility of estimating with any reasonable degree of certainty the receipts likely to accrue in 1942 it was felt that these reserves must for the present be maintained at a higher figure than would normally be necessary to provide against any emergency that may arise. It was, however, decided that as large a sum as practical should be invested in the various war loans.

St. Coombs Estate.—Details of the year's working will be found in the report of the Visiting Agent for 1941. Crop at 771 lbs. per acre and profit on working account at Rs. 302 per acre were both records for St. Coombs. 57.2% of the crop was supplied to the Minister for Food realising 81.88 cents per pound nett. The balance of the crop sold on the Colombo market realised Rs. 1.21 nett.

Considerable alterations were made to the firing room of St. Coombs factory during the year, thus bringing the layout into accord with modern requirements and providing additional room for investigational work. The two steel chimneys were also replaced by a masonry structure. The factory is in first class condition and little inconvenience should now be caused by the difficulty in obtaining replacements during the continuance of the war.

Labour conditions remained settled and it is satisfactory to record that no trouble occurred amongst the labour force during the year in spite of the rather disturbed atmosphere that prevailed in parts of the district.

Staff.—Mr. Redman King received a Commission in the Air Force Volunteer Reserve at the beginning of the year and his services were therefore no longer available. Major Tubbs remained on military duty and Mr. Lamb was also frequently absent on account of military training. At the end of the year intimation was received that the latter officer would receive a Commission in the C.P.R.C. and that his services would not be available to the Institute in 1942. Dr. Eden was on leave out of Ceylon for the first six months of the year.

Considerable changes had therefore to be made in the internal organisation of the Institute. The Director took over charge of the Agricultural Division until Dr. Eden's return and will be in charge of the Biochemical Division during Mr. Lamb's absence. The Entomological Division and the laboratory side of the Physiological Division were placed under the supervision of the Mycologist, Dr. Gadd, while Dr. Eden was placed in charge of field experimental work for the latter division, the junior staff being redistributed to meet the new conditions of working. Dr. Bond's main duties continued to be in connection with work on Phloem necrosis but he also took over charge of advisory work in connection with green manures and cover crops and the preparation of the herbarium. We were fortunate in still having the voluntary assistance of Mrs. Bond who has been largely responsible for the important work on Tea Selection which is at present the main pre-occupation of the Physiological Division. In this connection Mrs. Bond has given invaluable assistance, and the cordial thanks of the Institute are due to her for all she has done to keep these investigations going.

Mr. R. L. Illankoon, Small-Holdings Officer, Gampola, whose services were available for short periods during the earlier part of the year, was later on permanent military duty and the holdings' work in that area has been temporarily in abeyance.

Advisory Work.—War conditions have necessarily resulted in a considerable reduction in the volume of advisory work. The absence of so many Superintendents on military duty has naturally led to fewer enquiries being received from estates, while petrol and other restrictions have seriously limited the opportunities for planters to visit the Institute. Similar difficulties have led to a reduction in the amount of touring possible for the remaining members of the scientific staff.

In certain directions, however, the war has brought new problems to the front. The Institute has been able to render valuable assistance in regard to the reorganisation of manuring programmes necessitated by

war conditions while a considerable volume of work has been carried out in connection with the utilisation of local timbers for tea chests.

Conferences.—A T. R. I. Conference would normally have been held in 1941 but the conditions prevailing made it impossible to hold this.

Low-Country Research.—Representations were received from several District Planters' Associations in the low-country asking for the establishment of a Sub-Station in the low-country, so that increased attention could be given to the problems of chief importance at such elevations. The Director visited the District Planters' Associations concerned to discuss this question on the spot and the matter was subsequently considered by the Board. The decision was reluctantly reached, however, that, in view of the temporary reduction of the Senior Staff, adequate supervision of such work could not at present be provided and the matter must therefore stand over until more normal conditions prevail.

Publications.—In spite of reduced staff *The Tea Quarterly* was issued as usual. This will present still further difficulties in the coming year but every effort will be made to maintain publication. Bulletin No. 22, Annual Report for 1940, was also issued and a number of technical papers were contributed by the Scientific Staff to various scientific journals.

TECHNICAL.

In view of the necessity for condensing this report only the more salient features of the Institute's work will be mentioned here. For further details readers should refer to the separate reports of the various divisions.

Diseases and Pests.—During the year no new diseases of tea have been reported and none of the usual diseases have assumed undue prominence. Of the specimens sent in for report root diseases have as in previous years been the most common.

Investigational work in the Mycology Division has been chiefly concerned with Eelworm and Phloem necrosis. Particular attention has been paid to the susceptibility of different species of plants to *Anguillulina pratensis*, the species of eelworm which attack mature tea.

Observation has shown that generally speaking the eelworm readily enters the root system of the plants under investigation but in certain species the conditions prevailing in the plant are such that the female vacates the root again either before or after laying a few eggs only. The plants where this occurs, of which *Desmodium gyroides* and *Crotalaria anagyroides* may be quoted as notable examples, will therefore suffer little inconvenience from the attack and may be classified as relatively "immune."

It seems likely that similar considerations explain why the common root knot nematode *Heterodera marioni* normally attacks young tea only. The composition of the sap in all probability changes as the bushes mature and becomes unsuitable for egg-laying. It will only be under special circumstances leading to some modification of the sap that mature bushes will provide conditions suitable for the development of the pest.

Some investigations have also been carried out to ascertain how far *Anguillulina pratensis* can survive under starvation conditions. This work is of importance as an indication as to the feasibility of ridding infected areas of the pest. The results, which require further confirmation, suggest that by leaving the area completely fallow, so that no living roots exist for the eelworm to feed on, for a period of not less than eighteen weeks, a considerable measure of success may be achieved. This of course can be applied only where the tea has been uprooted with a view to replanting.

In regard to Phloem necrosis careful observations have been made as to the rate of spread of this disease in certain areas. The results from observation plots in the Kandapola area — the area most seriously affected — show that this may be as high as 1 per cent of the total per month which is a disturbing figure. On the other hand, the same plots have clearly indicated that by removal of infected bushes the rate of spread can be materially reduced while another encouraging feature is the fact that young supplies seem to be unaffected by the disease. A further interesting observation is that high jat tea appears to be relatively immune.

Though all the evidence so far collected points in an overwhelming manner to the conclusion that the disease is due to a virus, the nature of the transmitting agency has not yet been determined.

In the Entomological Division much time has been spent in a detailed examination of the data that have been accumulated in the past few years in regard to Shot-hole borer. Further details regarding the life-history of this pest were published in a recent number of *The Tea Quarterly* (Vol. XIV, pp. 5-22). Careful observations concerning the incidence of attack by shot-hole borer show that this is of relatively little importance in the first year after pruning. After this attacks rapidly intensify during the second year from pruning and then they again fall off. The fact that the main incidence of attack is confined to one period of the pruning cycle suggests that here again (*cf.* remarks on *Anguillulina pratensis)* there is some internal controlling condition in the bush itself which determines whether the bush will or will not be susceptible to attack and it is probable that it is this internal factor which is of chief importance. As to what this factor may be there is at present no clue but the observation opens up a further possible line of research.

Previous observations have suggested that shot-hole borer has few alternative hosts to tea but further work may modify this conclusion. During the past year two estates reported attacks by shot-hole borer on Gliricidia. The attacks were confined to the younger branches and no evidence was obtained that the insect had bred in this host.

Damage to young Albizzias from the larvae of *Terrias silhetana* and *T. hecabe* was more common than usual in the past year. Normally these caterpillars are kept in control by naturally occurring parasites but the latter were for some reason less in evidence than usual which may account for attacks being more severe. The remedial measures suggested will be found in the report of the Entomological Division.

It is satisfactory to record that Tortrix continue to be kept well under control by the Macrocentrus parasite liberated by the Institute and few estates now report any serious trouble from this pest.

Agricultural Chemistry.—War conditions have naturally resulted in considerable changes in cultivation programmes and the Institute has been able to give considerable assistance to estates in this connection. The utilisation of fertilisers in the most economical manner is obviously a matter of prime importance under war conditions and further work has only served to confirm the recommendations previously made in regard to delaying the first manuring application in the pruning cycle for a few months after pruning and grading the subsequent applications. Yields secured in the second pruning cycle of this experiment confirm the results obtained in the first cycle that by adopting this practice a more efficient use is made of the manure applied.

Preliminary results are given by the Agricultural Chemist of an experiment in regard to tipping and different types of plucking. There is some reason to doubt whether the normal Ceylon practice of tipping is really sound and there is also need for an examination of different systems of plucking. As the experiment has so far only been in progress for one year, the figures quoted in Dr. Eden's report cannot naturally be more than suggestive at this stage but later findings should prove of considerable practical importance.

On the laboratory side further work has been carried out on the decomposition of green manures and prunings in the soil and the influence of this process on the physical condition of the soil.

Physiological.—Further work on tea selection and vegetative propagation has been the chief occupation of the Physiological Division and, as already mentioned, we have been fortunate in the assistance we have received in these investigations from Mrs. Bond.

Yield records from nearly 2,800 bushes on St. Coombs have been completed and on 82 of the most promising of these manufacture tests have been made by the Biochemical Department. From such tested material

49 clonal plots have been planted up for further trial. The yield records of many of the selected mother bushes are exceedingly high and if the clonal tests give equally satisfactory results it is obvious much potentially valuable planting material will be available.

Work has also continued on the vegetative propagation of this material. By careful attention to detail a very high percentage of successful strikes is now obtained while at the same time the technique has been simplified. Experience has shown that little permanent gain results from pre-treatment of the cuttings with growth promoting substances such as Hortomone A and that the use of banjhi or growing shoots as the source of the cutting gives very similar results.

Details are also given in the Physiological Report of experiments on supplying. The results suggest, as might be expected, that the chief difficulty in establishing such supplies is the root competition from the surrounding tea.

Work on the identification of weeds, green manures, etc. has been placed under Dr. Bond who is also in charge of the herbarium. The latter now contain 295 sheets comprising 200 species. It is hoped to develop the herbarium so that it shall include specimens of all plants of interest to the tea industry.

Owing to the prevalence of weeds on estates during the past year there has been a general impression that these have been introduced in manures such as groundnut cake. The Institute has not however been able to collect the slightest evidence that this is in fact the case.

Among new green manures, two species of Tephrosia, *T. eriosemoides* and *T. toxicaria* and a species of Crotalaria, *C. recta,* show much promise and are undergoing further trial.

Biochemistry and Manufacture.—Work in this section has been considerably interrupted by the frequent absence of the Biochemist on military duty. Control of manufacturing experiments has also been made difficult by the fact that war conditions have naturally made it almost impossible for panels of tasters to meet in Colombo as hitherto to report on experimental samples.

The high tea prices generally prevalent on the Colombo market during the past year have had their effect in diminishing the number of enquiries received in regard to manufacture. On the other hand the war has brought into prominence other problems such as packing materials and many tests have been carried out on local timbers in regard to their suitability for tea tests. It is unfortunate that in spite of the experience of the last war little has been done in Ceylon to make available adequate supplies of such timbers and so to develop on sound lines a local chest industry

which would have been of great value in the circumstances now prevailing

Considerable progress has been made in the laboratory investigations on the fermentation of tea and the mechanism of this process is gradually becoming clearer. At the same time the research work being carried on in London on the Chemistry of tea is also beginning to throw light on the nature of some of the more important constituents of made tea.

Work on manufacture has been chiefly in connection with firing conditions and rolling. So far as firing is concerned the investigations are practically complete and the results are summarised in the report of the Biochemist. The work on rolling has been subject to many interruptions but useful information of practical importance in connection with batten types is being obtained.

The Biochemical Division has as before been responsible for the manufacture tests of individual bushes from the selection experiments.

Small-Holdings.—Owing to the mobilisation of Mr. Illankoon, the Small-Holdings Officer stationed at Gampola, work in this area has been more or less at a standstill during the past year. In the Southern Province, however, work has proceeded as usual and a successful competition was held at the end of the year. Considerable progress has been made in this area.

General.—Anticipating next year's report, it is obvious that research work in 1942 will be subject to still greater interruptions and, in fact, it seems likely that the time of the staff will be largely occupied with the question of food production on estates. Arrangements have however been made which should ensure continuity in the permanent field experiments.

Acknowledgments.—Our thanks are due to the Ceylon Association in London, the Planters' Association of Ceylon and the Ceylon Estates Proprietary Association who as always have done everything in their power to facilitate the work of the Institute.

Messrs. George Steuart & Co. and the Superintendent, Gonakelle Estate, have continued to afford us every help at the Passara Sub-Station; Messrs. Leechman & Co., and Superintendents of estates in their Agency have co-operated in the work on *Phloem necrosis*, and acknowledgments are due to the numerous other Agency Firms and Superintendents who have assisted in various ways.

Reference has already been made to the difficulties in regard to the tasting of experimental tea samples and particular thanks are due to Mr. R. H. Horne and those who have co-operated with him in this work

at great personal inconvenience. Amongst these must be mentioned Messrs. A. Pelly Fry, M. P. Saunders, H. W. T. Sherwood, C. J. Speer and R. C. Kerr. We are greatly indebted to these gentlemen and their firms

Special thanks are due to Messrs. Forbes & Walker for the trouble taken in the disposal and shipment of our teas and for assistance in numerous other directions.

Valuable advice and assistance have as usual been received from Mr. F. J. Whitehead, particularly in connection with the alteration to St Coombs Factory, and Mr. H. Tonks, our Visiting Agent, and to both these gentlemen our cordial thanks are extended.

Much help in our small-holdings work in the Southern Province was afforded by Mr. W. Amerasinghe, Chairman of the Wanduramba Village Committee, Mr. S. Abeywickreme, M.S.C., and the Headmen of the District and this has been much appreciated.

In conclusion, the Director desires to record his personal thanks to all members of his staff for their ungrudging and loyal service during the past year.

The Reports of the Scientific Staff are appended.

ROLAND V. NORRIS,

Director.

REPORT

OF

THE MYCOLOGIST

FOR 1941.

Staff.—In addition to his own duties the Mycologist had charge of the Entomology and Physiology Divisions during the year.

Dr. T. E. T. Bond has continued his study of the *Phloem necrosis* disease of tea, and, on the reorganisation of the Physiology Division, he took charge of the herbarium and of the botanical work involving identifications. His report on *Phloem necrosis* investigations is included here under that heading.

Advisory.—407 letters were received and 430 despatched; 299 consignments of diseased specimens were received for examination and report. No new disease of tea was recorded during the year, nor did any known disease become unduly prominent. Root diseases were as usual the most prominent, and judging from the specimens submitted, more attention has been paid to stem diseases.

Publications.—In addition to papers published in *The Tea Quarterly* the following articles have been issued from this division:—

Bond, T. E. T.—On abnormal flowers of *Primula vulgaris* Huds. grown in Ceylon. *New Phytologist,* XL, pp. 152-156 (1941).

— A leaf spot disease of annual Phlox. *Trop. Agriculturist,* XCVI, pp. 142-146 (1941).

— Leaf spot diseases of lettuce and Antirrhinum. *Trop. Agriculturist,* XCVII, pp. 62-67 (1941).

Gadd, C. H. & Loos, C. A.—Observations on the life-history of *Anguillulina pratensis. Annals of Applied Biology,* XXVIII, pp. 39-51, (1941).

— Host specialisation of *Anguillulina pratensis.* I. Attractiveness of roots; II. Behaviour of the parasite within roots. *Annals of Applied Biology,* XXVIII pp. 372-381, 382-388 (1941).

— A virus disease of *Ageratum conyzoides* and tobacco *Trop. Agriculturist,* XCVI, pp. 255-264 (1941).

Loos, C. A.—Some diseases of garden plants. *Trop. Agriculturist* XCVI pp. 22-27 (1941).

— A virus disease of *Emilia scabra*. *Trop. Agriculturist* XCVII pp. 18-21 (1941).

NEMATODES.

Host Specialisation of A. pratensis.—A study has been made of the behaviour of *Anguillulina pratensis* towards roots of various plants, viz. *Crotalaria anagyroides, Tephrosia vogelii, Desmodium gyroides,* turnip and tea seedlings, in an attempt to obtain a better understanding of why this eelworm appears to attack certain plants in preference to others. A full account of the work has been published in a technical journal. A few of the more interesting conclusions only will be mentioned here.

It is now generally accepted that by means of certain sense organs, the amphids, nematodes recognise their hosts owing to the excretion by the roots of chemical substances which are carried in the soil water. By moving from regions of low concentration to those of higher concentrations the nematodes are led directly to the excreting roots. In laboratory tests, *A. pratensis* was attracted to and entered the roots of the above mentioned plants; turnip was the least attractive. The later behaviour of the eelworms differed after entry into the various plants. These experiments indicated that a measure of attractiveness of roots alone does not offer a reliable criterion of the true susceptibility of such roots.

In tea and Tephrosia seedling roots the adult female worms settled down to a more or less sedentary existence. Larvae and eggs were found in close proximity to the parent thus forming nests of eelworms. After entry into Desmodium, Crotalaria and turnip seedling roots many of the adult females left the roots again either before or after laying a few eggs. Those worms which remained in the roots laid fewer eggs than those which entered tea or Tephrosia.

From field observations tea and Tephrosia would be regarded as susceptible whereas Desmodium and Crotalaria would be termed resistant. It is evident therefore that resistance to *A. pratensis* is not due to actual resistance by the roots to the entry of the nematode but to the fact that, after entry into the so-called resistant roots, the nematodes find their environment unsuitable. It is possible that whether an environment will prove satisfactory to the eelworms or not depends upon the chemical composition of the root juices, but the eelworm cannot determine the suitability or otherwise of the root for breeding purposes without entering. Otherwise it is difficult to understand why the eelworms enter Desmodium as readily as tea seedling roots.

Heterodera Marioni and Old Tea.—If the chemical composition of root juices affords the real clue to susceptibility or resistance to eelworm injury, it is also probable that the composition of such juices changes with the age of some plants. It is well known that the root-knot eelworm *(Heterodera marioni)* is a serious pest of tea seedlings but, although the worms occur in abundance in the soil of mature tea fields, injury to the adult tea roots is the exception rather than the rule. It is only in certain relatively small areas that *H. marioni* causes injury to adult tea roots. Evidence was obtained during the year that *H. marioni* larvae often enter adult tea roots without causing any injury. Either the larvae leave the roots again or fail to develop into mature worms. That is the position in most tea fields. But in other fields, usually at high elevation and often, though not always, in fields also liable to attack by *A. pratensis,* the *H. marioni* larvae cause severe damage after entry into the roots of mature bushes.

Sesbania Seedlings and Eelworms.—Wilted seedlings of *Sesbania caerulescens* and *S. microphylla* were found to have their roots heavily invaded by eelworms belonging to the genus *Aphelenchoides.* Wilting took place soon after germination and before normal foliage leaves had expanded. The soil used in the germination boxes had been collected from the drains of a tea field, and because of this the problem became of considerable interest. Investigations ultimately proved that the soil was too acid for these species of Sesbania, and that the eelworm attack only developed after the adverse soil condition had had a detrimental effect on the plants. When the infected soil was sterilised and thereby freed of the eelworm, the Sesbania plants grown in it wilted as before, but this time, of course, the roots were not invaded by eelworm. Sesbania seedlings grown in a more suitable soil remained healthy even when such soil was loaded with eelworms from diseased plants.

The same eelworm has been found in the roots of *Tephrosia vogelii* seedlings grown in sand in the laboratory, but no naturally infected plants have been found in the fields.

Mermith Worms.—In the Annual Report for 1939 an account was given of worms belonging to the family *Mermithidae* some of which were parasitic on tea tortrix. This year we have received, on 3 occasions, larvae of the same or very similar worms found in the soil when diseased bushes were being dug out. There is no connection between the diseases of tea and the presence of these worms which spend a part of their life below ground.

The larvae collected in 1939 were maintained in soil for more than one year during which time they had not become adult. They and the specimens collected this year died as a result of an attempt to culture them under conditions which would have allowed closer observation.

Effect of Starvation on A. pratensis.—Adult female *A. pratensis* worms collected from the root cortex of infected tea bushes were placed in a small quantity of water (0.5 cc.) in glass specimen tubes. Ten worms were placed in some tubes and 50 in others. Dry sand (2.75 gms.) which would pass a 60 mesh sieve was then added to absorb the water and the tubes were placed in a damp chamber to prevent the sand from drying. At intervals the eelworms were washed out of some of the tubes and the number alive and dead were ascertained. Only those worms which assumed the characteristic death position were counted as dead; others though immobile were recorded as living. It was not always possible to account for all the worms originally placed in the tubes, so in Table 1 in which the results are summarised, the number of worms found after a given period of starvation are expressed both as a percentage of those originally placed in the tube and of those actually found on examination.

From the figures given there it is evident that after 18 weeks without food, over 20 per cent of the worms were still alive.

TABLE 1

The survival of female *A. pratensis* after starvation in damp sand

Period of Starvation	No. of worms			Living worms as % of	
	Used	Dead	Alive	Recovered	Used
3 days	400	7	375	98·4	93·7
1 week	410	28	348	92·5	85·0
2 weeks	250	16	220	93·4	88·0
3 ,,	440	48	351	88·2	79·8
4 ,,	370	51	305	84·6	82·4
5 ,,	560	205	318	60·8	56·8
6 ,,	560	193	318	62·3	56·8
7 ,,	300	112	166	59·7	55·3
9 ,,	200	102	82	44·5	41·0
12 ,,	200	99	98	49·7	49·0
15 ,,	200	135	60	30·8	30·0
18 ,,	300	212	69	24·6	23·0

Some of the living mobile worms removed from the damp sand after a period of starvation were tested to ascertain whether they would enter living Tephrosia roots. Three worms were put into a drop of water on a microscope slide and a freshly germinated *Tephrosia vogelii* seed was placed so that the root tip entered the water. Such preparations were placed in a damp chamber for 24 hours before examination, after which they were macerated as described elsewhere, and the entries counted.

The results are given in Table 3 under the heading 'Damp sand only' from which it is evident that many of the worms which survive starvation lose the ability to enter living roots, at least under the conditions of this experiment. By the end of the 9th week although only 55 per cent of the worms had died as a result of starvation none of the survivors were able to bore their way into roots.

A further experiment devised to check this conclusion is described later.

Can A. pratensis Feed on Decaying Vegetable Roots?—It is well known that many species of eelworms feed largely upon decaying vegetation or on the fungi growing thereon and it has been possible to breed some such species in damp sand containing decaying root tips.

An experiment somewhat similar to the foregoing was set up. Adult female *A. pratensis* were placed in tubes of damp sand as before, but this time decaying root tips of *Tephrosia vogelii* were added to the sand. The decaying roots were prepared by removing roots from freshly germinated seed and boiling them to ensure death. A few days later when they had begun to decay they were used for this experiment.

At intervals the worms were washed out of the sand and counted. The results are given in Table 2.

TABLE 2

The survival of female *A. pratensis* after starvation in damp sand containing decaying roots

Period Weeks	Number of worms			Living worms as % of	
	Used	Dead	Alive	Recovered	Used
1	250	29	193	87	77
2	160	8	137	95	86
3	50	7	40	85	80
4	40	2	34	95	85
5	50	1	37	97	74
6	130	25	94	79	72
7	80	15	64	81	80

A comparison with the result given in Table 1 shows that the presence of rotting root in the sand did not materially increase the percentage of survivors until the fifth and sixth weeks.

The worms which were recovered from the sand and rotting root were tested as before for their ability to enter living *Tephrosia vogelii* roots. The results are given in Table 3, from which it may be seen that the presence of decaying roots in the sand did not materially preserve the worms' ability to attack roots after the 3rd week of starvation.

TABLE 3

Entries of starved female *A. pratensis* into *Tephrosia vogelii* seedling roots. The worms were washed out of damp sand or damp sand with rotting roots, and tested in water.

Period of Starvation	Damp sand only Number of worms Used	Entered	% Entries	Sand with rotting roots Number of worms Used	Entered	% Entries
0 days	240	189	79	—	—	—
3 ,,	188	113	63	—	—	—
1 week	222	111	50	165	116	70
2 weeks	216	68	31	135	96	71
3 ,,	351	69	20	39	25	64
4 ,,	294	86	29	33	7	21
5 ,,	312	30	10	36	11	33
6 ,,	315	8	3	93	17	18
7 ,,	169	3	2	63	7	11
9 ,,	84	0	0	—	—	—

A Further Experiment.—In order to verify the conclusions drawn from these experiments a further experiment was tried. Tubes were prepared as before but this time each tube contained 10 worms only. Some tubes contained damp sand only and others damp sand and rotting roots. At the end of the period of starvation instead of washing the eelworms out of the sand a germinated *T. vogelii* seed was placed in each tube and allowed to remain and grow there for 4 days. At the end of that time the seedling was removed, the roots macerated, and the eelworms which had entered were counted. The results are given in Table 4 from which it is apparent that the presence of decaying vegetable matter in damp sand does not enable *A. pratensis* to maintain its strength and ability to attack roots.

TABLE 4

Entries of starved female *A. pratensis* in seedling *T. vogelii* roots grown in the damp sand or damp sand and rotting roots in which the eelworms had been starved

Period of Starvation	Damp sand only Number of worms		%	Sand with rotting roots Number of worms		%
	Used	Entered	Entries	Used	Entered	Entries
0 days	140	120	86	90	81	90
3 „	100	67	67	100	84	84
1 week	50	28	56	50	34	68
2 weeks	50	22	24	50	22	44
3 „	50	18	36	50	12	24
4 „	50	14	28	50	19	38
5 „	50	22	44	50	0	0
6 „	50	16	32	100	13	13
7 „	50	2	4	50	18	36
9 „	350	35	10	350	33	10
12 „	100	1	1	100	2	2
15 „	100	0	0	100	2	2

Effect of Starvation on Egg-Laying.—It was noted, when washing eelworms from damp sand after a period of starvation, that neither eggs nor larvae were to be found in the sand.

It is known from previous work that the eggs of *A. pratensis* if placed in damp sand will hatch after a period of 12 days, so the absence of eggs and larvae from tubes in which female *A. pratensis* had been living for 2 weeks and more, is indicative that such worms will not normally lay eggs in that medium. Gravid females will deposit eggs in water for two or three days after which egg-laying under these conditions ceases. It seems probable, therefore, that although adult female worms are often to be found in soil, it is unlikely that they commonly lay eggs in that medium.

It was also noted in the experiments described above that roots entered by females, which had been starved for a week or more, contained very few eggs. Tests were therefore made with females which had been starved for 9 and 12 weeks. Tubes were prepared as before, each with 10 adult females. At the end of the starvation period, germinated Tephrosia

seedlings were placed in the tubes and allowed to grow for 1 or 3 weeks, not merely 4 days as previously. The numbers of females found in the roots on examination are given in Table 5 together with the mean number of eggs per female. The mean numbers of eggs (per female entering) normally laid by *A. pratensis*, *i.e.*, without being starved previously, are given in the same table. It will be seen that starvation resulted in a delay in the commencement of egg-laying and that at the end of 3 weeks only half the number normally laid were found. In the starved series only one out of 30 eggs, *i.e.*, 3.3. per cent, laid had hatched, whereas normally in that time 20.4 per cent have hatched. There is no reason to suspect that by starving the mother the incubation period of any eggs laid later will be prolonged. It is more probable that starvation reduces the strength of the worms. That is shown not only by the reduction in the number of worms capable of entering the roots after starvation but also by the delay in egg-laying after the females have entered.

TABLE 5.

The mean number of eggs laid by female *A. pratensis* in *T. vogelii* roots normally and after being starved for a period.

Time in weeks	Not starved		Starved 9 weeks		Starved 12 weeks	
	Females observed	Mean No. eggs laid per female	Females observed	Mean No. eggs laid	Females observed	Mean No. eggs laid
1	64	4·8	30	0·1	—	
2	73	12·9	—		—	
3	71	15·3	19	7.9	5	6·0
4	65	21·8	—		—	
5	67	21·8	—		—	

Practical Conclusions.—Although the above experiments do not afford complete proof that *A. pratensis* is an obligate parasite they suggest the possibility that *A. pratensis* might be starved out of soil if no living plant is allowed to occupy it and so supply living roots on which the eelworm might feed. A bare fallow of at least 18 weeks is necessary and a longer period would be preferable. Any replanting of infected soil should be preceded by bare fallow to weaken the worms by starvation and the possibility of reinfection should be guarded against. The prevention of reinfection would be a major problem unless large areas were starved simultaneously.

PHLOEM NECROSIS.

The following report has been contributed by Dr. T. E. T. Bond.

The disease has now been identified from 117 estates, only 4 new instances having been reported during the year in a total of thirteen consignments of necrotic or suspected specimens received. The further co-operation of estate superintendents in sending in specimens for diagnosis is again invited, and this will be particularly appreciated from those estates and districts in which the presence of *phloem necrosis* has not so far been confirmed. It is of the utmost importance that the Industry should be kept informed of any tendency for *phloem necrosis* to extend to the mid and low-country districts, and for this reason it is desirable that the fullest possible information should be available as to the existing distribution of the disease at the higher elevations.

Specimens received during the year included a group of shoots from an estate in the Passara district with a peculiar undulate or wavy habit of growth. The 'waves' or loops were almost semi-circular in shape, with the nodes situated at their furthest extremities. The shoots were not necrotic and the cause of their condition was not apparent. The wavy habit had been confused with the zig-zag condition which is commonly, but not invariably, associated with *phloem necrosis*.

Necrotic bushes are frequently noted in which regions showing severe symptoms of necrosis, with curled leaves and zig-zag shoots, give rise to apparently normal shoots of completely healthy appearance. Such shoots are produced usually in seasons of rapid growth and the question has arisen whether, in fact, they have "grown away" from the disease. Usually on microscopic examination, they are found to be almost as heavily necrotic as the more obviously diseased parts although, in both types of shoots, necrosis-free gaps, perhaps two or three internodes in length do occasionally persist. Thus the internal necrosis, affecting the phloem, and the external symptoms of zig-zag and leaf curl can develop to a certain extent independently of one another. Cuttings propagated from the apparently healthy shoots are usually markedly diseased in appearance and are indistinguishable from those obtained from other parts of the bush.

A specimen showing the condition known as "red in the wood" was received from the Hatton district. As the name implies, this involves a discoloration of the wood region, partly in the sap and partly in the walls of the vessels themselves, and it is visible to the naked eye in the broken off leaf stalk. It was occasionally confused with the brown discoloration due to *phloem necrosis*. "Red in the wood" bushes are not necessarily necrotic. They have been found on St. Coombs and occur chiefly by the side of drains and paths, a fact which suggests that the

condition may result from exposure of the roots or other abnormal water relationships.

Field Observations.—All the St. Coombs observation plots were recorded by the end of the first week in May. It is hoped to repeat these records annually at about the same time of the year. A total of nearly 2,000 bushes is involved and the record takes nine or ten days, allowing the mornings for field work and the afternoons for entering up the data. Taking the plots as a whole, the percentage of necrotic bushes now stands at 21 per cent, an apparent increase of 10 per cent during the year. In the last Annual Report (T. R. I. Bulletin 22, p. 40) it was noted that the disease on St. Coombs and at the lower altitudes generally was often difficult to identify with certainty owing to its less characteristic effects on the bush. This difficulty has been partly overcome by an improved method of examination for doubtful bushes which involves stripping small portions of bark from the stems (or roots, where practicable). Necrosis can often be detected by this means when its presence in the leaf stalk is uncertain. Some of the apparent 10 per cent increase in the St. Coombs plots during the year can be attributed to this improved method of diagnosis and it is not expected that a similar increase will be reported next year. The observation plots are probably not typical of the estate as a whole, where the incidence of *phloem necrosis* would be much lower than the figure given owing to the virtual absence of the disease from several fields. Where the disease occurs, however, there is little doubt that it is increasing in severity and bushes easily recognisable as necrotic can now be found without much difficulty. Detailed notes are being made and photographs taken of certain marked bushes at yearly intervals in order to obtain accurate information as to the rate at which deterioration takes place.

The large plot in the Kandapola district was recorded again as a whole for the last time in March, when the incidence of necrosis in the total of 985 bushes stood at 61 per cent — an increase of 8 per cent since the previous record in August, 1940 (*loc. cit.* p. 39). The plot was afterwards subdivided for a repetition of the rogueing experiment which is described in a subsequent paragraph. The rate of increase in the percentage of necrotic bushes, which works out at about 1 per cent of the total per month, corresponds closely with the rate of increase during the two-year period 1938-1940. Further confirmatory evidence of the predominantly bush-to-bush spread of the disease was obtained from this plot.

Rogueing Experiments.—The field experiment in progress in the Kandapola district, the inauguration of which was noted in the last Annual Report (*loc. cit.* p. 40) has been recorded twice during the year, in February and August. The three "treatments" which were carried out at the start of the experiment and are being repeated at each subsequent 6-monthly

recording, are as follows :—

(A). Control from which no bushes are removed.

(B). Removal of all bushes considered by the superintendent to be non-productive.

(C). Removal of all bushes marked by the Tea Research Institute as "necrotic" or "suspected."

(The lettering is that actually adopted for the experiment: it differs from that employed in the text of the last Annual Report).

No attempt has been made to trace the progress of the disease under the different treatments as a percentage incidence of infection, as is usually done in field recording, since the removal of bushes in the "B" and "C" plots would render the figure meaningless. Instead, attention has been concentrated on the behaviour of the bushes originally marked "healthy" and the experimental treatments can be considered in relation to the proportion of such bushes which remain "healthy" at consecutive records. Any bush marked "necrotic" or "suspected," even on a single occasion, must be counted out, since such a bush if occurring in a "C" plot would be removed. Bushes which are marked consecutively "healthy" are left undisturbed except for the occasional circumstance of their removal from a "B" plot on being judged non-productive.

Table I shows the results of this experiment to date :—

TABLE 1

Effect of "Rogueing" Methods on Behaviour of Healthy Bushes. First Experiment

Plot		No. of healthy bushes in August 1940	No. remaining healthy at each subsequent record	%
Field 1	A	81	51	**63·0**
	B	69	45	**65·2**
	C	67	58	**86·6**
Field 3	A	71	30	**42·2**
	B	62	42	**67·7**
	C	75	57	**76·0**
Field 11	A	60	26	**43·3**
	B	69	34	**49·3**
	C	68	46	**67·7**

In each field, the "C" plots show the highest percentage of "healthy" bushes which have remained "healthy" so far (or, the lowest percentage which have subsequently become "suspected" or "necrotic"), the "B" plots the next highest, and the "A" plots the lowest. For the whole experiment, the differences "A" < "B" < "C" are statistically significant at the 5 per cent level of probability, which implies odds of 20 to 1 against a purely chance interpretation.

The thorough rogueing of the "C" plots has thus considerably reduced the subsequent apparent rate of spread of the disease when compared with the untreated plots. That it has not prevented it entirely is not surprising, considering that the experiment has only been running for eighteen months. For one can safely assume that a proportion of the "necrotic" or "suspected" bushes recorded since August, 1940 were, in fact, infected before that date and have only subsequently developed recognisable symptoms. The statement made last year, that it may require a couple of years before a reliable diagnosis of the disease in a newly-infected bush can be made, still holds good. Then again it must be remembered that none of the plots are isolated in any way from infection from outside. The experiment was laid down on the assumption that "neighbour infection" or bush-to-bush spread of the disease was of far greater importance than any random or discontinuous dispersal. If this were not the case, no rogueing of diseased bushes *within small areas* could possibly check the spread of the disease in those areas. As already noted above, further direct evidence of bush-to-bush spread has been obtained during the year from other plots: the results of this first rogueing experiment appear to confirm the relative importance of this means of spread. The experiment must run at least for another two or three years before any definite conclusions can be drawn, but meanwhile it does point to rogueing as a possible, if costly, method of controlling the spread of *phloem necrosis*. It is interesting to note that the ordinary removal of non-productive bushes as recommended by the Tea Research Institute for estate practice also appears to have had a significant effect. Whether this will be maintained at the subsequent records remains to be seen.

A duplicate rogueing experiment was laid down in March on the big plot in Kandapola noted previously, and the first record taken in September. These results although not attaining statistical significance, and which are accordingly not given in detail, appear to confirm the tentative conclusions derived from the original experiment. Some difficulty is being caused here, however, by the high incidence (61 per cent) of the disease in the experimental area, the number of healthy bushes remaining in the "C" plots after the removal of all necrotic and suspected cases being undesirably low. The experiment will be continued for the time being, at any rate until after the next recording due in March, 1942.

A large-scale repetition of these rogueing experiments, carried out in the Kandapola district, has been suggested and might be well worth while: it is, however, impossible without considerable outside assistance in the field recording for which special training and experience would be needed.

Yield Figures.—A number of estate yield records have been examined with a view to establishing the effect of the disease on the yield trends of the affected fields. The yield figures as supplied by individual estates have been calculated as averages for successive pruning cycles and

expressed as deviations (deficiency or excess) from the averages for the estate as a whole excluding the particular field in question. In general, these calculations have provided good evidence of a marked decline in yield of the most heavily necrotic fields during the last ten years. That the decline has not been greater, especially on those estates that have been carrying out a rigorous programme of removing non-productive bushes, is evidence that the bushes removed have in fact been non-productive for a considerable length of time, and that their removal has been economically worth while even apart from any consideration of the control of *phloem necrosis*.

Examination of Supplies.—Special search was again made for *phloem necrosis* among 6-15-year-old supplies on various estates but no definite cases of the disease were found. In fact only one or two authentic instances of *phloem necrosis* in young plants in the field have occurred so far, so that the position in this respect is distinctly encouraging. As noted in a subsequent paragraph, the idea of a possible immunity in *high jat* supplies, which is suggested so strongly by these field observations, now seems likely to receive further confirmation from the experimental side.

Experimental Work.—The need for a reliable method of experimental transmission for the disease is still of paramount importance. Considerable progress has been made during the year and in one direction at least promising results have been obtained. The extreme slowness in the development of symptoms of the disease after inoculation is still the major difficulty and the virtual absence of the disease in young plants in the field while encouraging from the point of view of the future prosperity of affected estates tends to retard the pace of experimental work. Interpretation of results has been further hampered by the unexpectedly wide-spread occurrence of various kinds of necrosis some of which are distinguishable with difficulty from *phloem necrosis* in its earliest stages. Further work on the precise characterisation of the symptoms of *phloem necrosis* is being undertaken.

Grafting Experiments.—Numerous inarched plants and seedling grafts of various ages are still being maintained from previous experiments.

Nearly 250 root grafts were made between November, 1940 and February, 1941. These consist of a healthy scion cutting "whip-grafted" or spliced on to a piece of necrotic root. The survival rate has been low, and the time required for full union between stock and scion has been even longer than was expected. Probably at least six months are required. At the last recording of these plants, 12 out of 18 *low jat* scions examined were necrotic, while all of 16 *high jat* scions examined were still quite healthy. A further interval of a year or more must elapse before the symptoms recorded will be diagnosible with certainty as *phloem necrosis*

but this result so far is interesting as potential experimental evidence for graft transmission of the disease to *low jat* material. As soon as this result can be confirmed beyond doubt and is shown to be repeatable, all the previous failures to transmit the disease to *high jat* material can be viewed in a new light, not as negative and inconclusive results but as positive and highly significant evidence of immunity, or at least symptom tolerance, of the plants concerned. The demonstration of immunity demands as an essential prerequisite the demonstration of the potential effectiveness of transmission under the conditions of experimentation employed.

"Couple-grafting" was mentioned in the last Annual Report as a promising method of grafting to bushes in the field and about sixty more grafts have been made, using this process. The scion consists of a mature greenwood single node cutting from which a narrow strip of bark is removed from the opposite side of the stem to the leaf. A similar strip of bark is removed from the selected stock branch and the scion is placed in position so that the two exposed strips of tissue are in contact. The graft is tied with waxed tape, only the leaf (which is cut short) and the axillary bud being left exposed. Evaporation is thus reduced to a minimum. The method really bears a closer resemblance to budding than to most other grafting methods. Some batches of grafts made failed completely, but in others a high percentage of successful unions was obtained. The difference was probably related to the condition of the scion material and of the stock bushes at the time of grafting, although a certain amount of actual incompatibility between stock and scion bushes may also exist in tea as in other woody plants. Thirteen scions survived at the end of the year of which several had made fair growth of at least one flush period. If this growth rate is maintained, a first examination for *phloem necrosis* will be made in March or April next

"False Necrosis."—Brief reference to this was made in the last Annual Report, when an experiment to test the effect of crowding or water logging of the roots was mentioned. No conclusions have emerged so far from this experiment which is due for a final examination early next year.

The original type of necrosis to which this name was given was fairly easily distinguishable under the microscope from "phloem necrosis" proper: it was known to occur in mature bushes in the field, and in the early part of the year it was found on one estate with considerable frequency among the supplies. The necrosis was almost invariably confined to the leaves, which could be affected at all ages, and was not associated with curling or any other external symptom. There was no evidence to suggest that it was infectious or that it was in any way related to the *phloem necrosis* disease.

Later, a batch of seedling grafts was made using necrotic scion material, when a number of the seedlings, three months after grafting, developed marked symptoms, both externally and internally, of the type previously regarded as characteristic of *phloem necrosis*. The value of this result, which at first sight seemed so promising, was soon thrown open to doubt by the discovery of a closely similar type of necrosis in the ungrafted, control seedlings. (Little reliance can be placed on external symptoms of leaf curl, etc. affecting seedlings in the laboratory, since these are easily induced by slight insect and other injuries). Further search revealed that the necrosis was wide-spread in a number of seedlings grown under various experimental conditions and that in some plants it graded imperceptibly into a characteristic "false necrosis" of the type mentioned above. These observations have subsequently been confirmed for seedlings of several jats.

The apparent transmission result in the root graft experiment already mentioned where only the low jat scions appeared to have become diseased, is an ample illustration of the importance of being able to explain (and hence eliminate if possible) this "false necrosis." Its occurrence affects the validity of what is in other respects the most convenient method of recording experimental plants, namely by leaf-tip sections. Unless this difficulty is overcome, resort must be had to the more laborious and wasteful method of stem or root sections — which organs so far have been affected to a negligible extent — or, alternatively, the examination must be postponed for a sufficient number of years for the symptoms of *phloem necrosis*, if the disease be present, to become advanced enough to be externally as well as microscopically unmistakable. The information available as to the relatively slow rate of deterioration of infected bushes would suggest that to adopt this alternative *in its entirety* would put an effective stop to progress in experimental work for an indefinite number of years. Desirable as it may be to allow a certain number of infected plants to reach maturity, it would obviously be impossible to wait for this at each successive step.

There is little reason to believe that the necrosis appearing in young seedlings is identical with *phloem necrosis*, *i.e.*, that an actual and unforeseen transmission has occurred, although, of course, the possibility must not be overlooked entirely. The seedlings were of various types, including some high jat plants, and the necrosis appeared principally in seedlings raised in peat, *i.e.*, under somewhat abnormal conditions. The effect of abnormal water relationships and of injury to the root is being further investigated.

There has been no evidence to date for transmission of *phloem necrosis* by the seed either in naturally occurring seedlings or in those grown experimentally from necrotic seedbearers.

Insect Inoculations.—A number of earlier experiments recorded during the year have given negative results and have been discarded. Data obtained in conjunction with the Entomology division showed that cultures of brown scale *(Saissetia coffeae)* could be maintained under laboratory conditions for a period not exceeding three months. Further inoculation experiments to young healthy low jat seedlings have been carried out using insects from severely necrotic shoots.

Examination of Cuttings, Etc.—All the young cuttings raised since the middle of last year have been recorded. The results were satisfactory in that a very high degree of consistency was obtained, cuttings from necrotic bushes showing leaf curl at an early age with typical *phloem necrosis* in the leaf-tip sections in all but a very few instances, while no such symptoms were recorded from the cuttings from healthy bushes and very little "false necrosis" occurred in them. The position in this respect is more favourable here than in the case of the seedlings. About 35 necrotic and 120 healthy (low jat) cuttings are now big enough for use in grafting and other experiments, and many more should be ready in a few months.

In the course of recording the cuttings, root grafts, etc. a large collection of permanent slides was made illustrating different stages in the development of *phloem necrosis* and the different types of "false necrosis," for which a preliminary classification is now being worked out.

Further batches of cuttings will be needed from time to time and their propagation will be carried out under supervision by the Physiology division. A start was made before the end of the year with a batch of about 800 cuttings from 10 necrotic and 13 healthy bushes.

The oldest necrotic cuttings on their own roots are now nearly four years old. They are small bushes and are obviously necrotic in appearance throughout. Several necrotic bushes transplanted in their entirety from the Kandapola and Nuwara Eliya districts have retained their characteristic symptoms in the new growth produced during a similar length of time. Even more striking as an instance of the persistence of necrotic symptoms in tissues formed in a completely different environment are some of the earliest inarches and seedling grafts. In the former the necrotic scion was a shoot a few inches long, in the latter it was a single node cutting similar to those used for the ordinary propagation work, yet in both cases a growth of probably many hundred times this amount has been produced which is severely necrotic throughout and has the characteristic external symptoms of the disease *although maintained by an apparently completely healthy root system.*

The usual criterion for a virus disease, *i.e.*, in the absence of any visible parasite, is graft transmissibility and admittedly from this point of view the evidence obtained so far from graft transmission experiments with

phloem necrosis is still not entirely convincing. But it is difficult to conceive of any condition other than a virus disease capable of reproducing itself in transplanted bushes, in cuttings, and above all in grafted scions and in each case apparently to an indefinite extent. Taking this with the available evidence from field observations and from the experimental work as a whole, support for the hypothesis of a virus origin for *phloem necrosis* becomes overwhelming.

"Minor Element" Nutrition Experiments.—Among other theories which have been brought forward from time to time, the hypothesis of a deficiency or excess of some minor nutritional element has received most publicity. Two previous experiments which have given completely negative results can be mentioned in this connection. These are a field experiment in Kandapola designed to test the effect of adding small quantities of boron to the fertilizer mixture, and an experiment carried out at St. Coombs involving spraying certain bushes with very dilute solutions of chromium salts. The two theories respectively of a deficiency of boron and an excess of chromium as causative agents of *phloem necrosis* have received no support from these experiments.

Anatomical Investigations.—A detailed knowledge of the anatomy of the vegetative organs of the tea bush, particularly as regards the structure and development of the phloem tissue, is of primary importance as a background to the experimental investigations. The trouble experienced with "false necrosis" of various kinds is ample illustration of this.

During the year, the anatomical work has been extended to cover the leaf, so that a fairly complete picture is now available of the phloem anatomy and general structure of the flush shoot as a whole. Data have also been collected to illustrate the periodicity of development of the apical bud and this information is being correlated with anatomical structure. The whole of this section of the work is now ready to write up for publication.

C. H. GADD,
Mycologist.

REPORT

OF

THE ENTOMOLOGIST

FOR 1941.

Staff.—The Entomologist proceeded on active service on February 13th, 1941, and the Mycologist assumed charge of the Entomological division in addition to his own duties.

Advisory.—623 letters were received and 667 despatched. 227 consignments of insects were examined, of which 132 related to Nettle grubs.

Nettle Grub.—Nettle grub was reported this year from 11 estates in Uva, as compared with 21 estates in 1940, which were in the Badulla (5), Passara (4) and Madulsima (2) areas. On 5 estates the pest was present to a greater or less extent throughout the year.

The chief species of nettle grub concerned in these attacks were *Natada nararia, Thosea cervina, T. recta* and *Narosa conspersa* with *Spatulifimbria castaneiceps* following in smaller numbers. *Parasa lepida* (the blue striped nettle grub) was reported on three occasions. This nettle grub is rarely associated with the previously mentioned species but appears by itself. The larvae are gregarious and consequently are more easily controlled.

Tortrix Parasite.—An article has been published in *The Tea Quarterly* (Vol XIV, pp. 93-97) containing data concerning the efficiency of *Macrocentus homonae* as a parasite of tea tortrix. The evidence there published indicates that the parasite is highly efficient and that it is holding the tea tortrix in check very effectively

From time to time requests are made that the parasite should be liberated on certain estates because a tortrix attack is starting. This year, requests were received from the Bogawantalawa, Dimbula, Kandapola and Pussellawa districts, and in every case the parasite was found to be already established on the tortrix. The parasite is now widely distributed through all the tea districts. Estates which experience a tortrix attack and have doubts that the parasite *Macrocentrus* is at

work, should send 50 to 100 tortrix larvae packed in a wooden box to the laboratories for examination. Should the parasite not be found in the specimens, arrangements would be made for a liberation at an early date.

Tea Aphis and Empusa sp.—In the course of a laboratory experiment in which tea seedlings growing in pots were infected with the tea aphis *(Toxoptera aurantii)* it was noted that the aphid colonies on two plants were parasitised by a fungus which proved to be a species of *Empusa*. The effect of the fungus is shown by the following. On one plant 6 adult females had been placed. By the 15th day the aphids on that plant numbered 96 after which there was no increase, and they were all dead by the 23rd day. On the other plant a colony, started from 10 adults, consisted on the 23rd day of 131 individuals of which 119 were dead. Two normal unparasitised colonies each originating from one female consisted on the 23rd day of 841 and 610 individuals respectively of which only 61 and 60 respectively had died. As the plants were covered by bell jars the conditions were favourable for fungus growth, so it is improbable that equal effective control by the fungus would be obtained in the field except under very favourable climatic conditions.

In order to ascertain to what extent the parasitic fungus, *Empusa*, occurred naturally in the field from which the aphis had been collected for experimental purposes, 50 bushes in one row were examined for aphis attack. 72 colonies were found and of these 18, or 25 per cent, were infected by the fungus. This survey was made on October 3rd, 1941, and arrangements have been made for more examinations to be made later.

Albizzia Butterfly.—One of the most persistent and destructive pests of Albizzia is the caterpillar of a little yellow butterfly with black edges to the wings. The larvae of two species commonly occur on Albizzias, viz., *Terias silhetana* and *T. hecabe*, and devour the foliage. The older caterpillars are dull green with a pale stripe along the sides and have either conspicuous black heads *(T. silhetana)* or green heads (*T. hecabe*). The pupae are usually attached by the tail end to the bare midribs of the plants on which the larvae have fed.

This pest is particularly destructive to seedlings because the complete loss of foliage at that stage may be fatal, whereas larger and older plants may be wholly or partially defoliated without coming to much harm. The life cycle is very short occupying only about one month from the laying of eggs to the emergence of the butterflies. Consequently, any treatment considered necessary should be prompt and carried out before the maximum damage is done. The specimens sent to the Institute for identification are usually full grown caterpillars and pupae. At that stage they have done all the damage they are likely to do, and if they have been feeding on young seedlings, the damage may be irreparable.

On young Albizzias the young caterpillars can be killed by spraying them with a solution of soft soap at the rate of 1 lb. soap to 6 gallons water. The efficacy of this spray depends largely upon wetting the caterpillars with the solution. As a poisonous spray, King recommends lead arsenate 1 lb., soft soap 1 lb., water 50 gallons. As an alternative to spraying, dusting with Paris Green diluted with 8 times its weight of sifted lime should be effective on young plants. Older trees may be lopped and the loppings buried to destroy the larvae and pupae.

The pest is likely to occur at any time of the year but St. Coombs records indicate that from October to January is its most prevalent period.

Normally, the caterpillars are more or less efficiently controlled by a Chalcid parasite *(Brachymeria megaspila)* and a species of Tachinid fly. During 1941 the parasites were absent (they were not found at St. Coombs nor the Passara laboratories) and defoliation of Albizzias was considerable.

Fear has been expressed that these caterpillars may turn their attention to tea. On a few occasions the caterpillars have been found to feed on tea, but that has usually happened after the Albizzias have been stripped of their leaves and the caterpillars have fallen to the tea beneath, where they have fed for a day or two prior to pupating. Attempts to induce young larvae to feed on tea have resulted in the caterpillars dying prematurely.

The Lobster Caterpillar *(Stauropus alternus* Wlk.)—This is one of the minor pests of tea. According to records at Peradeniya and St. Coombs only two serious outbreaks have been recorded during the last 50 years and both were in the Kalutara district. As remarked by Green, were it not for these outbreaks this peculiar caterpillar would be recorded more as a curiosity than as a pest. Green also mentions Lobster caterpillar as a typical example of an "insect which may exist for a number of years without attracting attention, and may then suddenly assume the proportion of a serious pest."—(R.B.G. Circ. Ser. II, No. 5, p. 97, 1903). In the Passara district, Lobster caterpillars appeared in rather large numbers during the months of February and March. In a collection of 50 caterpillars only two larvae were parasitised by a Hymenopteron which turned out to be the Braconid, *Apanteles stauropi* Vieresk. The Tachinid parasite, *Carcelia (Exorista) gnava* Mg., recorded at Peradeniya, failed to appear. A 'wilt' disease was the chief natural controlling factor.

The opportunity was taken to rear some of the caterpillars in the insectary when the following life-history data were noted.

Largest No. of eggs deposited=194

Egg stage=6-7 days (average of 500 eggs).

Larval period=37 days (average of 5 larvae).

Larval instars=7 lasting 2, 5, 5, 5, 5, 6 and 10 days respectively.

Pupal stage=12 to 13 days. (Average of 23 pupae).

Longevity of male and female moths=19 and 20 days respectively.

SHOT-HOLE BORER.

Estate Investigations.—The request made last year that estates, on which shot-hole borer is regarded as being the cause of serious loss of crop, should allow the Institute to investigate their yield records, met with such poor response that investigation along that line had to be abandoned, at least temporarily.

Life-history.—Data collected in 1936 have been studied in an attempt to ascertain more about the life-history of this boring beetle. A full account of the work has been published in *The Tea Quarterly,* Vol. XIV, pp. 5-22, so. the methods by which the information was obtained and the conclusions arrived at need not be discussed here at length. The average times spent by the beetle in its various stages of development were: From commencing boring the gallery to egg-laying 8 days; egg period 7 days; larval stage 15 days; pupal stage 7 days. The life-cycle, egg to egg, is about 40 days. Evidence was also adduced to show that more eggs were laid than adults were formed. This indicates a high mortality of offspring within the gallery although they are well protected from enemies and the vagaries of the weather.

Hard and Light Plucking Experiment.—This experiment (see earlier reports) was terminated in December, 1941. It was originally laid out in a field with a two-year cycle but the experiment was extended for a third year which is now completed. The complete data have not yet been fully studied but it is hoped that a full account of the experiment will be published in an early number of *The Tea Quarterly.* Data collected during the early part of the experiment has been used for a study of the attack made by shot-hole borer, an account of which is published in *The Tea Quarterly,* Vol. XIV, pp. 132-146.

Shot-Hole Borer Attack.—Tea bushes in plucking are attacked by shot-hole borer mainly during the second year from pruning. In the first year the attack is very light; it increases during the second year and finally fades out in the third year from pruning. This fact does not

appear to have been noted previously but to the writer it seems of considerable importance. It raises numerous questions many of which cannot yet be answered. For instance, why is a tea bush in plucking more attractive to the beetle in the second year from pruning? Can the susceptible period be reduced by cultural or other treatment? Is the absence of shot-hole borer at high elevations the result of climatic conditions acting directly on the beetle or indirectly through the type of growth produced in the bush as a result of these conditions?

Alternate Hosts.—From time to time the tea shot-hole borer has been reported as attacking other plants. In his report for 1938 (T. R. I. Bulletin 19, p. 35) King stated "So far, although short galleries may be driven in many different plants, no case has come to light of the beetle being able to maintain itself and raise a brood in the same way as it does on tea." In his report for 1940 (T. R. I. Bulletin 22, p. 46) he gave the results of certain inoculation experiments and showed that of the plants experimented with *Mimosa bracaatinga* was the only one in which the tea shot-hole borer proved capable of raising a population as it does in tea.

If, as shown above, the tea shot-hole borer will attack tea freely only at definite stages in the pruning cycle when apparently the bush contains wood particularly suitable for raising a brood, it would appear probable that the beetle would breed in other trees also only when the wood conditions were just right for the purpose. This point had not been taken into consideration in the inoculation experiment mentioned above, and it is possible that the beetle would have raised a brood in those trees it entered, had the wood been of the right age or provided the requisite conditions.

Shot-hole borer and Castor oil plant.—The shot-hole borer that attacks castor oil *(Ricinus communis)* is normally slightly larger than that which attacks tea and is regarded as a distinct variety. It was noticed that the castor beetle does not normally attack castor till the trees are at least 2 years old, so it was decided to carry out a further inoculation experiment using the tea shot-hole borer and castor trees at a time when the unprotected branches were being attacked by the castor beetle. The tea borer beetles entered the castor branches and of 19 galleries dissected five were found to contain 33 inmates consisting of eggs, larvae, pupae and adults. It is evident therefore that the tea-shot-hole borer can breed within castor branches if they are of the right age or stage of development.

Shot-Hole Borer and Gliricidia.—Shot-hole borer was first recorded in *Gliricidia sepium* in 1926, since when no further attack has been noted until this year when, in June, two estates in the Welimada district

reported that their trees were attacked. An inspection showed that young branches 3 to 5 feet in length were selected for attack and that older branches were not affected. The attack became apparent during the South West Monsoon when strong winds caused branches to break; the fracture was always at a shot-hole gallery. Of the galleries dissected, about 90 per cent were found to be empty and the remainder contained solitary beetles only. There was no evidence that families had been reared in the galleries.

Other Hosts.—The undermentioned plants were observed to be attacked by shot-hole borer beetles and examination of the galleries revealed the presence of young in all of them with the exception of *Casuarina* and *Grevillea* which contained solitary females only. *Achania* sp. (an ornamental shrub), *Casuarina equisetifolia* (whip tree), *Crotalaria usaramoensis, Erythrina lithosperma, Grevillea robusta, Mimosa bracaatinga, Tephrosia candida, T. vogelii.*

Desmodium ovalifolium was found to be attacked by the borer *Xyleborus morstatti.*

Breakage of Branches.—In the Annual Report for 1940, data were published concerning the number of branches broken between May, 1939 and November, 1940 from 100 bushes on Gonakelle Estate, Passara, (Elevation 3,520 feet) as the result of shot-hole borer attack. As the field in question was pruned in November/December, 1938, the figures show that during a two-year pruning cycle an average of 4.68 branches per bush were broken. The great majority were broken during the period June, 1940 to November, 1940, *i.e.*, at the end of the second year from pruning.

Somewhat similar data were collected during a manurial experiment on Wikiliya Estate, Balangoda (Elevation 1,500 feet), in 1939. The bushes were pruned in October, 1938, and the pruning cycle was one of 18 months. The breakages were counted at 3 week intervals between March 22nd, 1939, and January 24th, 1940.

During the period a total of 5,435 breakages occurred in 5,774 bushes which gives an average of 0.94 per bush for a period of 10 months. The breakages found in the plots on each occasion, together with the treatments applied to the plots, are shown in Table I.

Until January 3rd, 1940, the largest number of breakages found on any occasion was 378 but on that date and the following when the experiment stopped, the numbers rose to 1,139 and 1,492 respectively. During the first year from pruning the breakages were almost negligible. In the 14th month the number increased markedly.

TABLE 1

The number of broken branches found in the manurial experiment plots on Wikiliya Estate, Balangoda, pruned October, 1938.

	Manurial Treatment						
	Nil	Artificials only	Compost only	Compost and artificials	Green manure only	Green manure and artificials	
No. of bushes	951	991	986	967	881	998	
Date	NUMBER OF BREAKAGES						Total
1939							
22nd March	14	20	8	23	6	9	80
26th April	52	52	51	56	45	68	324
10th May	30	23	23	18	25	27	146
17th May	16	27	20	24	24	23	134
7th June	43	34	44	39	20	31	211
28th June	20	19	16	14	16	21	106
19th July	20	27	22	23	21	22	135
9th Aug.	31	38	41	35	24	37	206
30th Aug,	37	35	30	34	30	32	198
20th Sept.	20	18	22	26	20	25	131
11th Oct.	24	28	26	31	29	33	171
1st Nov.	69	64	64	71	50	60	378
22nd Nov.	52	50	40	46	45	56	289
13th Dec.	47	49	58	48	52	41	295
1940							
3rd Jan.	145	165	244	195	193	197	1,139
24th Jan.	232	259	231	225	296	249	1,492
Total	852	908	940	908	896	931	5,435
Mean per bush	·90	·92	·95	·94	1·02	·93	·94

The number of breakages affords some indication of the extent of shot-hole borer attack as the branches would not normally break unless previously attacked by the borer. The evidence here supports the conclusion mentioned previously, viz. that shot-hole borer attack is very slight during the first year from pruning and that it develops during the second year.

From May 17th, 1939 to January 24th, 1940, the diameters of the broken branches at the break were measured. In all, 4,885 broken branches were measured and their classification by size is shown in Table 2. The mean diameter of the broken branches is 7.9 mm. or 0.3 inches. Fifty-eight. per cent of the breakages occurred in branches between 6 and 8 mm. in diameter.

TABLE 2

Broken branches classified according to their diameter at the breakage

Diameter of branch mm.	Number broken	Diameter of branch mm.	Number broken	Diameter of branch mm.	Number broken	Diameter of branch mm.	Number broken
4	43	8	825	12	132	16	9
5	412	9	596	13	69	17	5
6	930	10	406	14	50	18	3
7	1090	11	295	15	17	19	2
						20	1

Loss of Crop Experiment.—As stated in the last report an attempt was made to interpret broken branches in terms of loss of crop. The method was to remove a given number of branches from bushes on an estate (St. Coombs) where shot-hole borer does not occur and to ascertain what loss of crop resulted.

With this object in view 200 bushes in a block on St. Coombs Estate were selected and of these 100 were chosen at random for treatment. In March, 1940, when the bushes were one year old from pruning and before any branches were removed, experimental plucking was started and was continued weekly for 25 weeks. The yield of each bush was recorded individually. At the end of this period 5,699 gms. of tea had been harvested from the 100 bushes chosen for treatment as compared with 5,572 gms. from the bushes to be kept as controls.

In September, 1940 at the end of the 25 plucking rounds two side branches were removed from each of the treated bushes. The diameter of the branches at the cut was 8 mm. which corresponds with the mean diameter of broken branches on Wikiliya estate. Plucking was then continued for 23 rounds at weekly intervals until February, 1941.

During this latter period the treated bushes gave 7,630 gms. (dry weight) as compared with 7,724 from the controls. If the treatment had had no effect on yield and if all bushes during the second plucking period gave crop in proportion to that obtained during the first period, a yield of 7,900 gms. would have been expected from the treated plots. That amount is 270 gms. in excess of what was obtained. In this way an estimate of 270 gms. or 3.4 per cent. is obtained as the loss resulting from the removal of two branches per bush.

No very great reliance can be placed on this estimate of loss, viz. 1.7 per cent per branch removed. When the records of individual bushes in this experiment are examined, it becomes evident that their behaviour over the whole period was very variable. Expressing the yield of the second period as a percentage of the yield of the first period, one of the untreated bushes showed a decrease of 7.8 per cent and another an increase of 121 per cent. The corresponding extremes shown by the treated bushes were — 11 and 128 per cent. The conclusion that the breakages of branches must result in loss of crop is an obvious one but the accurate estimation of such loss is one of considerable difficulty.

C. H. GADD,
Acting Entomologist.

REPORT

OF

THE AGRICULTURAL CHEMIST

FOR 1941.

Staff.—The Agricultural Chemist was absent on furlough from January 17th to July 15th, 1941.

Mr. B. T. Schuiling resigned his appointment as Field Assistant with effect from October 31st.

Mr. F. P. Jayawardana was transferred from the Staff of the Plant Physiology Department with effect from July 31st, 1941.

At the time of proceeding on furlough the Agricultural Chemist relinquished the charge of the investigations of the Plant Physiology Department. On his return, the field experiments formerly associated with the Plant Physiology Department were transferred to the Agricultural Chemistry Department on the basis of a permanent reorganisation. The result of this rearrangement is that all the cropping experiments undertaken by the Institute are now under the charge of one person and are executed by one staff instead of by two as formerly.

Advisory.—302 letters were received and 285 replies despatched. A large part of the correspondence of the department continued to be concerned with changes in manurial schedules necessitated by war conditions. There has been a progressive diminution in the variety of manures available, but there has been no actual shortage except in respect of potash manures. It is noteworthy that arrangements for equitable distribution of types of fertilizer that were below normal amounts have worked smoothly and satisfactorily, and that despite the inevitable increase in costs there has been no evidence of a markedly reduced scale of manuring.

Publications.—Since the last report the following papers have been contributed to scientific journals:—

Studies in the Yield of Tea IV. The Effect of Cultivation and Weeds on Crop Growth. T. Eden. *Empire Journal of Experimental Agriculture*, 1940, Vol. 8, pp. 269-279.

Determination of Ammoniacal and Nitrate Nitrogen in Decomposed Plant Material. J. G. Shrikhande. *Industrial and Engineering Chemistry (Analytical Edition)*, 1941, Vol. 13, pp. 187-188.

INVESTIGATIONS IN PROGRESS.

Analytical Methods.—The survey of chemical composition of samples of soil and plant material drawn from the manuring experiments which was mentioned in the previous report has proceeded. It has been hampered by inability to secure adequate supplies of chemicals owing to war conditions. In addition a rapid method for determination of soil phosphate which it was intended to use failed entirely on our soils. Dr. Shrikhande has worked out a new method of wide application and considerably shorter than the standard method of Hall. A description of this method has been prepared and despatched for publication.

Green Manuring and Soil Condition.—For some time past the investigations into green manuring have been largely concerned with the decomposition processes in relation to the release of nutrients, but the effect on the physical condition of the soil has not been lost sight of. It has been asserted in some quarters that the decomposition of green manures in the soil causes excess acidity and that although tea is known to flourish in, and prefer, a distinctly acid soil, such decomposition may push the soil reaction too far over on the acid side. This view has no foundation in fact under conditions prevalent on tea estates. If vegetable matter is decomposed under waterlogged conditions by anaerobic micro-organisms, hyperacidity will develop. This sometimes occurs at the bottom of an ill-made compost pit. The breakdown of vegetation in green manuring operations in the field is an aerobic process.

In connection with an investigation on building up the physical structure of the soil into soil crumbs, to which reference will be made later, the modifications in the properties of a soil when different green manures are added have been under examination for some time. The following are the changes in reaction that occur after one month's decomposition. In the examples given, green stuff was added to the extent of 15 per cent by weight of the soil.

Table 1.

Effect of Green Manuring on Soil Reaction

Treatment	pH of Soil
(1) Control (soil only) ...	5.38
(2) Soil plus tea pruning leaf ...	6.46
(3) Soil plus sunflower *(Tithonia diversifolia)*	8.26
(4) Soil plus lawn grass cuttings ...	6.71
(5) Soil plus *Tephrosia vogelii* ...	7.52
(6) Soil plus *Tephrosia vogelii*, leached with water for 48 hours ...	7.60

By the end of a month's active decomposition the morphological structure of the sunflower and *Tephrosia vogelii* was completely destroyed: tea and grass still showed undecomposed remains. When dissipation of the bulk of the carbonaceous part of the green manure has taken place there still remains a considerable amount of basic material in the form of the mineral content of the vegetation itself and the ammonium compounds formed by the ammonification of the surplus protein. That this basic material is not merely transient is shown by the fact that the leaching of the soil produced no increase in acidity. Since for some years we have encountered sporadic cases of damage to tea from *alkalinity* it may be as well to give a reassurance that the markedly alkaline reactions shown in these data are not likely to occur in practice, since in these experiments the soil was deliberately loaded with green stuff to a degree unknown in the field. The essential fact is that green manuring does not tend to acidify a soil, rather the opposite.

In a previous report (1938, Bulletin 19, p. 57) mention was made of the connection assumed by some workers between soil tilth and the sticky mucus formed by rotting vegetable matter. In particular, attention was drawn to the anomalous behaviour of tea pruning leaf which produces little or no mucus. During the past six months, steps have been taken to explore the relationship between mucus formation and the building up in the soil of crumbs whose presence, size, and persistence determine the tilth and ease of cultivation of a soil. As a preliminary the question of persistence of soil crumbs under adverse conditions is being studied. The water stability of the tilth of diverse types of soil is being determined, and so far the results show that tropical soils of quite different types are remarkably stable, much more so than temperate soils. It has been shown in the practical cultivation trials of this department that it is not rain and severe drought which destroy the tilth of our soils but the constant trampling *(Tea Quarterly,* 1941, XIV, 50). This fact has thus been confirmed by the more detailed work on water stability of soils just mentioned.

In addition to examinations of local and other soils, the actual building up of an agricultural soil from infertile flood silt is in progress. The results though promising are not yet sufficiently definitive for report.

FIELD EXPERIMENTS.

(1) **Experiments on Time of Application of Manures.**—In the last report full details were given of the yield increments produced when the application of fertilizers was delayed after pruning for periods of 3 and 6 months respectively. In the second pruning cycle in which this delay has been practised, similar and confirmatory results have been recorded. The three-month delay has not been so profitable as formerly, and the effect has to a great extent worn off. The six month delay, *i.e.*,

a delay till about the time of normal plucking after tipping, has fully justified itself. Twenty months after pruning and after fifty plucking rounds, the gains in yield are as follows:—

		lb. per acre
Gain due to 3 months' delay	...	7.3
Gain due to 6 months' delay	...	93.6

In order to follow up the effect of varying doses of manure at varying times in the pruning cycle, a new experiment was started in September, 1939, and full details of the design are given in the previous report. Six months after pruning every plot received, in addition to phosphate and potash, a standard dose of 30 lb. of nitrogen. Ten months later one third of the plots continued to have 30 lb., one third received 45 lb. and the remainder 60 lb. of nitrogen. In the final manuring the changes were rung still further on the arrangements of nitrogenous doses.

For the first period of ten months during which differential treatments were being given to these plots, the following were the yields per acre.

Table 2.

Yields for incremental doses of nitrogen.

Nitrogen in fertiliser		Yield
@ 6 months	@ 16 months	lb.
30 lb.	30 lb.	908
30 lb.	45 lb.	861
30 lb.	60 lb.	938

The extreme difference between these yields is only some 8.5 per cent of the mean yield and at the level of replication employed this difference is not reliable enough to assign to manurial treatment. It is at first sight rather surprising that 30 lb. of nitrogen in addition to normal soil fertility can produce a 900 lb. yield, but it must be remembered that the site of these plots was specially chosen for uniformity. With regard to the failure of higher doses to show immediately a yield increase, it may be remarked that the field in question carries a heavy stand of young grevilleas. The question of the partition of fertilizers between tea and accompanying shade trees is at present problematic. This experiment may provide data for further work upon the subject.

In the same experiment, comparisons between sulphate of ammonia, nitrate of soda and a mixture of both supplying equivalent amounts of nitrogen, were incorporated. There is up to the present no reliable difference between the behaviour of the three treatments.

Table 3.

Yields from equivalent doses of nitrogen in different forms.

Kind of nitrogen	Yield per acre lb.
Sulphate of ammonia	922
Nitrate of soda	869
Mixture of sulphate of ammonia and nitrate of soda	916

(2) **Experiment on Tipping and Plucking.**—The prevalent method of bringing tea into bearing in Ceylon is entirely different from that employed in N. E. India. The three noticeable differences are (1) the less severe pruning prevalent in India, (2) the plucking of the flush at a given level after recovery from pruning without any tipping operation, (3) the custom of plucking to the fish leaf on every occasion except at the first round. The Indian Tea Research Officers who have seen our method suggest that we may be losing crop needlessly by not adopting something approaching their method.

One important difference between Assam conditions and ours is the length of the pruning cycle, particularly at higher elevations. In annual pruning in Assam, very little wood is pruned out: the majority of the frame remains. The questions whether without tipping we can produce a plucking table with sufficient plucking points on it, and whether without leaving a leaf above the fish leaf we can preserve enough foliage to serve the bush over an extended pruning cycle, are points requiring consideration.

Accordingly at the beginning of 1941 an experiment was started to explore these questions. The comparisons chosen were:—

(1) Tipping at 4" *versus* Direct plucking at 6" above pruning cut.
(2) Plucking over a leaf *versus* plucking to the fish leaf.
(3) Taking out banjhi *versus* leaving banjhi.

These three comparisons were combined in the eight possible ways giving eight individual treatments. On this first occasion the tipping comparison was not exactly as stated above. Some shoots were found to have grown higher than the proposed plucking level by the time the experiment was laid out. These were removed from the plots designed for direct plucking. This amounted to giving the plots a first tipping at an immature stage. All subsequent shoots were plucked as they reached the plucking table

After a year's plucking the following are the yields per acre :—

Table 4.

Yields in lb. from different types of plucking

Normal tipping	Direct plucking	Plucked to fish leaf	Plucked over single leaf	Banjhi removed	Banjhi left
677	770	813	634	813	634

These results have not so far been subjected to a complete statistical analysis, but it is evident that marked differences in yield are being caused by the treatments. They should not be regarded as anything more than an interesting interim statement. Obviously the testing time will be later in the cycle. Appearances are deceptive, and the plots plucked to the fish leaf look very unattractive already.

(3) **Experiment on Cultivation and Weeding.**—This experiment is reaching the close of its second pruning cycle. It will be convenient to leave a statement of its results till the whole cycle can be considered. Here it may be recorded that despite weather favourable to intense weed growth, there is no sign of increased deterioration in cropping power on the selectively weeded plots The general results are similar to those already reported, *i.e.*, weeds cause a small decline in crop. and intensive cultivation a still smaller drop in yield. Neither loss exceeds 6 per cent.

T. EDEN,

Agricultural Chemist.

REPORT

OF

THE PLANT PHYSIOLOGIST

FOR 1941.

Staff.—The Mycologist assumed sole charge of the work of the Plant Physiology Division on the departure of Dr. Eden on leave on January 17th, 1941. On his return on July 15th, 1941, the work of the division was reorganised so that field work involving the collection of crop records was transferred to the Agricultural Chemist's Division. At the same time Mr. F. P. Jayawardene was transferred to that division as Field Assistant.

Botanical work involving the identification of weeds, green manures and cover crops was transferred to the Assistant Mycologist who also took charge of the herbarium. The section of this report headed Weeds, Cover Crops. Green Manures, etc., has been supplied by Dr. Bond.

Mrs. T. E. T. Bond, M.Sc. has again given valuable voluntary assistance in the work of this division throughout the year. Her active interest in vegetative propagation of tea and general plant physiological problems has greatly facilitated the work of this division. It is a pleasure to record our appreciation of that assistance.

Advisory.—183 letters were received and 198 despatched.

Tea Seed.—Complaints were received from a few estates regarding the poor quality of the seed this year. The main characteristic of the poor seed was the large percentage of light seeds which could be separated by floating in water. Many of the seeds were normal in size with well formed shell but the tissues within the shell were not sufficiently developed to fill the cavity. Some seeds were almost empty. The worst sample, freshly collected from the trees, gave on test the low germination capacity of 15 per cent. On one estate the condition improved during the season and a satisfactory quality was later obtained. That improvement was not however achieved on all estates. The cause of the poor quality is unknown.

Deaths from Collar Pruning.—In the course of an experiment described in the Annual Report for 1938 (Bulletin No. 19) 2,271 bushes were collar pruned in May, 1937. Dead bushes which had made no stem growth since pruning were removed in the following years as follows: 1938, 21; 1939, 46: 1940, 33; 1941, 38 (includes 31 which had made no growth since pruning but were still alive)— Total 138 or 6.1 per cent.

The majority of the bushes in this experiment were healthy when collar pruned, so a greater percentage of deaths may be expected if collar pruning is carried out on badly rotted frames at lower elevations, where root starch reserves are lower. It should be noted that a small percentage of bushes remained alive for over 4 years after collar pruning without making any new stem growth.

Deaths Amongst Supplies.—In the experiment referred to above certain plots were entirely replanted, and others had supplies interplanted between existing bushes so that there were twice the number of plants in the row. In 1937 at the beginning of the experiment 5,592 two-year-old stumps were put out. By the end of 1940 a further 1,841 stumps were used as supplies to replace dead plants, making a grand total of 7,433 stumps put into that area. By the middle of July, 1941 the total number of deaths amongst those supplies was 2,019 or 27.2 per cent.

It may be of interest to ascertain in what plots the greatest number of deaths occurred. The plots in which supplies were put out were as follows :—

1. Replanted area. The area had been cleared and replanted at the same spacing as before, viz. 3½ feet.

2 Replanted and interplanted. This area was cleared and replanted at the old distance between the rows (3½ feet) but with twice as many plants in the row.

3. Pruned and interplanted. The bushes were clean pruned and supplies placed between the bushes in the rows.

4. Collar pruned and interplanted. The bushes were pruned at ground level and interplanted as for plots 2 and 3. The wounds were tarred and covered with soil.

TABLE 1

Deaths during 4 years among supplies—2-year-old stumps

Plot Treatment	Planted No.	Deaths No.	Deaths %
1. Replanted	1,244	191	15·4
2. Replanted and interplanted	2,458	387	15·7
3. Pruned and interplanted	2,127	1,022	48·0
4. Collar-pruned and interplanted	1,604	419	26·1

It is evident from Table 1 which gives the number of deaths occurring in the various plots that the greatest death rate (48 per cent) occurred in the plots which had been pruned and interplanted. In these plots young plants were placed between well grown bushes and the root competition they met with must have been very severe. The supplies interplanted with collar pruned bushes would also meet heavy root competition but not so severe as in the normally pruned plots, because after collar pruning the recovery is slower and the water requirement of the recovering bushes is less. In the completely replanted plots root competition would be negligible and it is in these plots that the death rate was least (15 per cent).

Growth and Root Competition.—It is to be expected that if root competition causes mortality amongst supplies it will also have a detrimental effect on their rate of growth. The diameters of the supplies were measured 6 weeks after planting and again at 6-month intervals. The mean measurements are given in Table 2 from which will be seen that although there was no real difference in the size of the plants at the time of planting, the effect of root competition became evident by the end of the first year in those plots where the supplies were planted between normally pruned bushes. By the end of the second year the effect of root competition from collar pruned bushes began to take effect. Three and a half years after planting the effect of root competition with mature bushes as judged by the growth of supplies was very marked.

TABLE 2.

Mean diameter of supplies planted as 2-year-old stumps, measured at ground level at 6-month intervals.

Plot Treatment	Mean diameter in inches							
Months	0	6	12	18	24	30	36	42
1. Replanted	0·22	0·23	0·30	0·38	0·57	0·79	0·92	0·97
2. Replanted and interplanted	0·21	0·22	0·30	0·37	0·55	0·74	0·86	0·93
3. Pruned and interplanted	0·22	0·22	0·26	0·28	0·31	0·32	0·34	0·38
4. Collar-pruned and interplanted	0·21	0·22	0·29	0·35	0·49	0·58	0·67	0·74

The data here given have a direct bearing on the difficulties of supplying old tea which are well known.

SELECTION AND PROPAGATION.

Selection.—The work of selecting bushes on a yield basis from all fields on St. Coombs was completed during the year. Tests were also made by the Tea Technologist of the factory qualities of a number of bushes previously selected for yield. A few statistics are given in Table 3.

TABLE 3
Selection Work

	1941	Previously	Total
Yield records completed	273	2,489	2,762
Bushes tested for factory characteristics	46	36	82
Bushes chosen on yield basis	16	93	109
Bushes chosen for yield and manufacture	25	8	33
Clones planted for observation	30	19	49

A simplified method for the selection of high-yielding tea bushes was discussed by Dr. Eden in *The Tea Quarterly*, Vol. XIV, pp. 98-102.

Propagation.—The technique used for the vegetative propagation of tea has been reviewed in *The Tea Quarterly*, Vol. XIV, pp. 102-105 by Dr. Eden and Mrs. Bond. Attempts to improve the technique have continued and the results of some of the lines investigated are given below.

Banjhi v. Growing Shoots.—An experiment was started at the beginning of December, 1940, to compare banjhi and growing shoots as sources of cuttings for propagation. Tea cuttings from banjhi shoots and from growing shoots from each of 32 different bushes were prepared for planting in a mixture of equal parts of peat and soil in the open. The propagation bed had clinker drainage beneath it. Half the cuttings of each sort were shaded with fern rather more heavily than is normally done in a seed nursery, and the other half were shaded with hessian carried on wooden supports. The numbers and percentage rooted after 3, 4 and 5 months are given in Table 4.

TABLE 4
Comparison of the rooting of cuttings from banjhi and growing shoots propagated under fern and hessian shade.

Rooting period	Type of Shoot				Shade			
	Banjhi		Growing		Hessian		Fern	
	No.	%	No.	%	No.	%	No.	%
3 months	240	75	215	67	230	72	225	70
4 ,,	278	87	267	83	278	87	267	83
5 ,,	294	92	290	91	295	92	289	90

It is evident from Table 4 that the percentage strike under all conditions was eminently satisfactory and that there is no real difference between the results obtained from banjhi and growing shoots or between hessian and fern shade. As the experiment was carried out mainly in dry weather, these results obtained in the open are very encouraging.

Effect of Nutrients.—An experiment was designed to determine the effect of sucrose and urea solutions on the rooting of cuttings when used as a pretreatment before planting. The solutions used were as follows:—

1. Water only.
2. Sucrose 0.85%
3. do. 1.7%
4. Urea 0.15%
5. do. 0.30%
6. Sucrose 0.85% + Urea 0.15%
7. do. 0.85% + do. 0.3%
8. do. 1.7% + do. 0.15%
9. do. 1.7% + do. 0.3%

Each solution was applied for 3 different times, viz. A, 12 hours; B 18 hours; C, 24 hours. There were thus 27 different treatments, and 20 cuttings were used for each.

540 cuttings were prepared from a number of bushes and well mixed The stalks of 60 cuttings were placed in each of the above solutions so that the solutions could be absorbed, much as cut flowers in a vase absorb water. 20 cuttings were removed from each solution at the above stated times and planted in January, 1941, in a mixture of peat and soil (50 per cent) in a thatched propagation shed. After 3½ months the cuttings were removed and the numbers rooted were recorded. The results are given in Table 5.

It is evident from the figures given in Table 5 that all the cuttings pretreated with sucrose and urea solutions have given better results than these pretreated with water (solution 1). The best results were obtained with urea alone at the weaker strength (solution No. 4), but when sucrose was added to urea at the weaker strength (solutions 6 and 8) the results were no better than with sucrose alone.

Dr. Tubbs reported a somewhat similar experiment in his Annual Report for 1938 (Bulletin No. 19). He totally immersed his cuttings in a solution containing 2.0 per cent dextrose plus 0.1 per cent urea. He found that in general the pretreatment had no significant effect upon rooting.

In a later experiment, described below, a further test was made with urea in a 0.15 per cent solution. On that occasion no markedly beneficial result was obtained from that pretreatment. There is therefore no clear evidence that any real benefit is obtained as a result of pretreatment with such nutrients as sucrose or urea.

TABLE 5.

The number of cuttings rooted 3½ months after pretreatment with solutions of Sucrose and Urea. 20 cuttings were used for each treatment.

Solution		1	2	3	4	5	6	7	8	9	Total	%
Time of pretreatment	12 hrs.	10	14	10	15	13	12	10	11	7	102	57
	18 ,,	10	9	13	17	12	16	14	8	15	114	63
	24 ,,	9	14	15	17	14	11	14	15	14	123	68
	Total	29	37	38	49	39	39	38	34	36	339	63
	%	48	62	63	82	65	65	63	57	60	63	

Hortomone A.—In the last annual report an experiment was described in which the growth regulating substance, Hortomone A, was used on cuttings, some of which had been in a medium (peat and sand) conducive to callus formation for a month. In the experiment now to be described the growth regulator was applied immediately the cuttings were made. Hortomone A was used, alone and in conjunction with a urea solution, at a strength of 1 part Hortomone A to 320 parts water. Urea solution at 0.15 per cent was also tested again. The pre-treatments were :—

1. Water (W).
2. Hortomone A 1:320 (H)
3. Urea 0.15 per cent solution (U).
4. Hortomone A (1:300)+ urea (0.15%) (HU).

Two-hundred cuttings from each of 4 bushes were prepared and pretreated as in the previous experiment by allowing the cuttings to stand with their stalks in the above solutions for 18 hours, 50 cuttings from each bush being used for each treatment. Immediately after treatment the cuttings were planted in a mixture of peatmoss and soil (50 per cent) in a propagation shed. The cuttings were planted in May and were examined after 2, 3 and 4 months. The numbers found to have rooted at each examination are given in Table 6.

The cuttings treated with Hortomone A showed the greatest percentage rooted after 2 months, but by the end of the fourth month the cuttings treated with water only had rooted equally well as the Hortomone A treated cuttings. Any effect that the Hortomone may have had was in speeding up slightly the rooting during the first two months. That effect however was not so apparent when the hortomone was used in conjunction with a urea solution. The urea solution alone gave no better result than did water.

TABLE 6.

The number and percentages of cuttings rooted in 2 to 4 months after pretreatment with Hortomone A and Urea. 200 cuttings were used for each treatment

Rooted after	Treatment							
	W		H		U		HU	
	No.	%	No.	%	No.	%	No.	%
2 months ...	57	29	79	40	57	29	66	33
3 months ...	107	54	124	62	109	55	105	53
4 months ...	144	72	144	72	149	75	140	70

TABLE 7.

The number and percentages of cuttings from different bushes rooted in 2—5 months.

Bush	2 months		3 months		4 months		5 months	
No.	No.	%	No.	%	No.	%	No.	%
1,016	135	68	170	85	180	90	181	91
331	8	4	62	31	149	75	182	91
216	107	54	176	88	187	94	194	97
483	9	5	37	19	61	31	80	40

That the cuttings from some bushes root more readily than others is also well illustrated by this experiment. It may be seen from Table 7 that of the 4 bushes used, Nos. 1,016 and 216 rooted very well. No. 331 was a slow starter but by the end of the fifth month a satisfactory number had rooted (91 per cent). No. 483 was not only a slow starter but the number rooted at the end of five months was not satisfactory (40 per cent).

The pretreatment of cuttings seems hardly necessary when 85 per cent root within 3 months as did Nos. 1,016 and 216. Hortomone A seemed to have little or no beneficial effect on the slower rooters, Nos. 313 and 483. At the end of the second month, of the Hortomone A treated cuttings from these bushes only 4 and 5 per cent respectively had rooted as compared with 1 each of the water treated cuttings. At later examinations there was no notable difference between the rootings of the Hortomone A treated and water treated cuttings.

Coir dust as a rooting medium.—In view of the difficulty in obtaining peat moss for propagation work a trial was made with coir dust as a substitute. The results were so very unsatisfactory that it cannot be recommended for the purpose. Very little improvement was achieved when the coir dust was mixed with soil and it became evident that coir dust should be avoided as a medium for the propagation of tea cuttings.

Cuttings v. Seedlings.—We are indebted to Mr. M. C. Dias of Sirikandura Estate, Matugama, for the following information. In June, 1940, two small areas were planted with cuttings and seedlings in alternate rows. The cuttings were then 6 months old from their original planting; they had been 3 months in peatmoss and 3 months in baskets. While in baskets they each received a teaspoonful of a general estate manure mixture. At the time of planting they were from 8 to 12 inches in height. Seedlings of approximately the same height were selected in a nursery and removed to the field with a ball of earth; a transplanter was used. The planting distance was $3\times3\frac{1}{2}$ feet and 20-inch holes were cut. The plants in one area (A) had 18-inch protection baskets and in the other (B) they were shaded with fern. The plants were watered during the drought and the soil was protected with green manure loppings.

In June, 1941, *i.e.*, one year from planting in the field, the plants were measured; the results are given in Table 8.

TABLE 8.

Comparison of the growth of cuttings and seedlings.

Plot	No. of plants	Mean height ins.	Mean girth 1 in. above soil level ins.
A. Cuttings	24	63	.65
A. Seedlings	23	54	.60
B. Cuttings	22	55	50
B. Seedlings	19	45	.47

Both cuttings and seedlings made better growth in plot A than in plot B, due to the fact that soil conditions were better in plot A. In both plots the cuttings made slightly better growth, on the average, than did the seedlings. Four cuttings and two seedlings had failed to grow after centering in June, 1941, (*i.e.*, 5 months after centering).

These figures tend to remove any fear that may exist concerning the relative growth of cuttings and seedlings. When established, the growth of cuttings should compare favourably with that of seedlings.

WEEDS, COVER CROPS, GREEN MANURES, ETC.

The following report has been contributed by Dr. T. E. T. Bond.

Advisory Work.—Fifty-three enquiries were dealt with from 25 estates. They concerned 24 species of weeds and cover crops, and 13 species of green manure plants and shade trees. Most of these plants were of quite common occurrence in various parts of the Island and two only deserve special mention. Both of these were weeds, for the identification of which, with other information, we are indebted to the Botanist, Peradeniya. They are as follows:—

Polanisia (Cleome) graveolens.—This was sent in from the Deraniyagala district and is an erect herbaceous plant with blue flowers and prominently elongated seed pods. It is a member of the family *Capparidaceae* and is closely related to several other species which are indigenous to Ceylon. *P. graveolens*, however, is a Tropical American species and has apparently been recorded from Ceylon on a single previous occasion only, namely from Peradeniya in May, 1938.

Euphorbia geniculata.—This is a typical erect growing herbaceous or slightly shrubby species of *Euphorbia*, of the kind known in England as "spurges." It occurred suddenly in abundance in a new clearing in the Opanaike district which had had cattle manure in the holes before planting, a few years previously. The 'seeds' or fruits of the plant are hard and woody and the suggestion was made that they had been introduced with cattle manure and had germinated in a favourable season after lying dormant in the soil — perhaps on being brought nearer the surface during forking. Information was subsequently received that the plant was abundant in chena cultivation within five miles of the estate, so that its occurrence in locally available cattle manure would be quite likely. This plant is not native to Ceylon, and was recorded first in this country in May, 1932, and from time to time since then. Further outbreaks would appear probable.

Weed Seeds and Manures.—The general abundance of weeds this year, and the occurrence of sudden outbreaks of unfamiliar species, of the type described above, has led to wide-spread belief in the possibility of the occurrence of weed seeds in certain organic fertilizers, the use of which has increased under wartime conditions. *Several samples of such fertilizers have been tested and in no case has there been any evidence whatever that they contained viable weed seeds.* In fact, the conditions of manufacture, in the great majority of cases (and especially in those where the product is finely ground), would eliminate entirely any chance of such weed seeds as might initially have been present surviving in a viable condition. On the other hand, there is ample evidence from all parts of the world for the great powers of survival, *in the soil,* possessed by numerous weed seeds, and for their germination in abundance, often after long periods of dormancy, during especially favourable seasons. That the weather during the last two years has been particularly favourable for the growth of weeds, no one will doubt, and there is little doubt also that no further explanation will be needed to account for the crop of weeds obtained.

T. R. I. Herbarium.—Sixty-five sheets were added to the general collection during the year, including 33 new species. The herbarium now contains 299 sheets of 200 species, chiefly weeds and green manures, and a few shade trees. Great improvement has been effected during the last eighteen months in the technique of pressing and mounting specimens and an effort has also been made to include in the herbarium specimens of all the weeds growing in the vicinity of St. Coombs. The ultimate aim is to have specimens of all plants of interest to the tea industry throughout Ceylon. A well kept herbarium in time should become of considerable scientific value beyond the mere identification of specimens: it should for example include sufficient material to illustrate the range of variability of a given species under different climatic conditions and should be accompanied by a record of all that is known of the life history, utilisation, or methods of eradication of the plants represented in the collection.

New Green Manure Species.—During the year eleven new leguminous cover crops have been under observation in small plots in the laboratory compound. The seed of these plants was kindly supplied by Mr. E. Wilson Smith, who obtained it for us from the Department of Agriculture for S. Rhodesia. The collection included four *Crotalaria* spp., five *Sesbania* spp. and two species of *Tephrosia.* The two latter were outstanding for their compact habit of growth and dense foliage and might be distinctly promising as cover crops. These are, (1) *T. eriosemoides,* (2) *T. toxicaria. Crotalaria recta* was the best among the others. All three species will be submitted to further trial under tea next year.

Mimosa bracaatinga Hoene.—This new green manure was imported from Brazil by the Department of Agriculture in 1937. At the Passara Sub-Station (elevation 3,500 feet) the trees continue to grow luxuriantly. The trees which were originally raised from seed sown in baskets late in 1937 are now 30 feet in height. By July 1938, when the plants were 8 months old, the tallest plant measured 7 feet. Some of the plants were transplanted when 6 months old and these are doing as well as those which were left in the nursery. All trees were cut down to a height of 3 feet when they were 8 months old. They all stood up to the strong gales which Uva experiences during its period of dry weather from June to August. Trees were observed to flower first in November-December, 1940. Flowers were again observed in September, 1941. Seed is being collected and will be available for distribution on application.

On St. Coombs, a single specimen tree of *Mimosa bracaatinga* growing in the laboratory compound began to flower for the first time in December, 1941. Other trees planted out in the tea have not yet flowered. These are growing quite satisfactorily and are now about 15 feet high.

C. H. GADD,
Acting Plant Physiologist.

REPORT

OF

THE BIOCHEMIST

FOR 1941.

Staff.—Personnel remained unchanged. 17% of the Biochemist's time was spent on military duties whilst frequent breaks in continuity tended to disorganise the work of the department.

As almost all the experimental work in the factory is ultimately dependent on the kind services of Colombo Tea Tasters (tasting in London having already been abandoned) the scope of this work is limited by the difficult circumstances under which the tasters themselves work. Drastic changes in the activities of this department are anticipated in January, 1942.

Advisory.—252 letters and reports were received and 234 despatched. As reported last year the number of enquiries from Agency Firms concerned with materials and supplies has constituted a feature of our advisory activities whilst the number of enquiries from estates concerned with manufacturing problems have again been few in number compared to pre-war years.

Towards the end of the year when the local market began to show more discrimination, preliminary to the fall in prices, there was a sharp increase in advisory work in connection with manufacture. Since this department started advisory activities the number of enquiries has always been closely connected with the state of the market.

This attitude towards research is not a desirable one and the general situation was dealt with in a *Tea Quarterly* article entitled "A Review of Tea Manufacture in 1941." The most opportune time for progressive changes in tea manufacture is when prices are most remunerative but there is a distinct tendency to "let well alone" both on the part of the proprietors or agents, and superintendents.

When the market falls, research cannot be expected to prop it up again; many of the problems which arise during times of depression are entirely of remote economic origin and are not technical or subjects for reasearch in Ceylon.

The present Biochemist has eight years' experience of manufacture in Ceylon and has visited a thoroughly representative selection of factories during that time. Records of a very large number of visits by Dr. Evans were also available. So far as one can generalise it is quite certain that the main cause of trouble in tea factories and of comparatively unsatisfactory prices in falling markets is obsolete machinery and equipment. Driers which are difficult to control, and the absence of moisture content testing apparatus, are the most fruitful sources of trouble. During one period when some 25-30 factories were visited on account of unsatisfactory firing it was remarkable that only in one case was a moisture content apparatus available. It is only very seldom that we receive enquiries about firing troubles from estates which determine moisture contents regularly and the trouble is then usually due to obsolete firing machines which are practically uncontrollable.

Next in the order of common troubles is rolling equipment which is unsuitable for the tasks imposed. The size and number of rollers are often quite unsuitable for the crop and the size of drier. That these are the factories which most commonly write for advice cannot be mere coincidence.

When prices are bad the plea is that the estate cannot afford new equipment and there have been cases where money could not be obtained for a thermometer which would have made all the difference between normal firing and spoiling a large percentage of tea fired. How can a drier be controlled without a thermometer? The vicious circle of indifference when prices are good and false economy when prices are bad has far more to do with progress than it should have and is a very serious handicap to the research worker who has to take a realistic view of the industry as it is rather than the industry as it might be.

The tea industry in Ceylon must watch its competitors in other countries to avoid serious trouble in the future and it would appear desirable in many cases to allocate a percentage of profits to a reserve for the systematic improvement of factory equipment. Now, when prices are remunerative, is the time for estates with poor equipment to plan improvements which will enable them to compete more successfully in times of depression. Any factory with a record of comparatively unsatisfactory prices would be well advised to examine equipment, especially along the lines advocated in the various articles upon organisation which have appeared in *The Tea Quarterly* and which we summarised in "A Review of Tea Manufacture in 1941."

It is important to realise that not only quality or rather *standardised* or *consistent* quality depend on organisation in the factory but also labour and power costs. Lack of organisation invariably means wasted labour and power, with unnecessarily long machine hours and consequent high cost of upkeep.

ANALYTICAL.

1. *Ash Contents.*—As a result of enquiries in connection with food and drug regulations the ash contents of 71 Ceylon teas were determined. The results were reported in *The Tea Quarterly* during the year. Our thanks are due to the Government Analyst and the Agricultural Chemist of the Department of Agriculture for the loan of platinum apparatus to supplement our equipment and expedite this work.

2 *Aluminium Inserts for Roller Battens,*—Samples of aluminium inserts for roller battens were sent in by an Agency firm in connection with unsatisfactory wearing properties. The aluminium contained a large percentage of iron and it was suggested that scrap metal had been employed for their manufacture. This proved to be correct.

3. *Effect of Water on the Colour of Tea Liquor.*—The main effect of water on the colour of tea liquor appears to be a question of pH value. Different samples of a well bulked tea were cupped out in buffered solulion of different pH values and the colour measured by means of a Lovibond Tintometer. The amount of yellow colour in the liquor remained constant but the red showed a marked increase up to pH 7.0 above which figure auto-oxidation occurred.

pH of liquor.	No. of red units measured by Lovibond Tintometer.
4.6	1.5
5.2	2.0
5.9	2.3
7.0	3.1
7.4	3.1

The substance used to make up the buffer solution did not affect colour

	No. of Lovibond Units. Red.	Yellow.
Liquor made with distilled water at pH 5.2	3.0	17.0
Liquor made with buffer solution at pH 5.2	3.0	17.0

The judicious use of bicarbonate of soda to increase the colour of tea liquors in districts where the water has markedly acid reaction is therefore possibly a subject worth investigation.

Tea leaf itself is acidic in nature as the pH of the liquors of 23 different samples of tea collected from various parts of Ceylon varied only between the narrow limits 4.68 to 4.96 when cupped in distilled water.

The incorporation of alkalis during manufacture to bring about a neutral reaction might be feasible and would certainly bring about a marked improvement in the colour of, say, up-country teas where colour as well as flavour and quality were difficult to attain. The process however would be difficult to control as any excess would cause dull brownish liquors.

BIOCHEMICAL.

Progress with this continues. Two papers under the heading "Studies on the Fermentation of Ceylon Tea" were published in the Biochemical Journal.

I. The Nature of the Enzyme System by J. Lamb & H. B. Sreerangachar.

II. Oxidizing Enzymes by J. Lamb and H. B. Sreerangachar.

Part III Respiration and Tea Fermentation by H. B. Sreerangachar has been received by the Biochemical Journal and is being considered for publication in due course .

As the work is highly technical it is not proposed to give any details of it in this report. The practical bearing will be reported in due course.

GENERAL MANUFACTURE.

Firing Experiments.—The current programme of firing experiments was completed at the end of the year. Some of the results have already been reported in *The Tea Quarterly* and the completed results will be published early in 1942.

There does not appear to be much scope for further experiments on the present method of firing as the experiments now completed cover most of the practical points which arise in the firing process. New methods may be investigated in the future but it is scarcely probable that firing by means of hot air will be superseded by any other method and as the present machines are effective, simple and economical there is little incentive for further investigation especially under war time

conditions. The results may be summarised as follows:—

1. Temperature. 190°F. was found to ensure the best keeping qualities without marked detriment to pungency, quality and flavour. Firing at 160°F. gives teas of better flavour and quality but the keeping qualities are uncertain.

2. Moisture content. Firing to 3% ensures the best and keeping quality.

3. Time of firing. At 190°F., 20 minutes approximately was found to give the best results.

4. Final Firing. Final firing at 160°F. for 15 minutes does little harm but it is best avoided if the moisture content is not above 4%. Above 4% final firing is advisable. Teas which have risen to 6% can be final fired down to 3% without marked detriment to quality.

5. Packing hot. Packing teas whilst hot was found to be detrimental to quality.

Rolling Experiments.—Owing to interruption due to war conditions little progress has been made. The work is divided into two main lines:—

1. The systematic investigation of batten types to discover the best batten types for
   (a) Twisting
   (b) Cutting.

2 The investigation of fundamentally different methods of expressing juice from tea leaf in order to expose it to the air for fermentation.

The main trouble with existing methods is that expression of juice is a gradual process and that as fermentation does not commence until the juice is exposed to air the final result is a mixture of everything between unfermented and badly overfermented juice.

Two lines of approach to the problem are:—
   (a) The Clivemere roller.
   (b) A method for many years used in laboratory investigation of plant juices involving freezing of the leaf. Freezing causes disruption of plant cells in the same way as freezing water is liable to burst water pipes.

MANUFACTURE OF LEAF FROM FIELD EXPERIMENTS.

Selection.—The manufacture of leaf from individual bushes selected for high yield is proceeding. This is the only manufacture of leaf from field experiments being carried out at present.

Acknowledgments.—Our most sincere thanks are due to the following: Mr R. H. Horne and to Messrs. Forbes & Walker for arranging team meetings and tasting samples from indvidual bush manufactures, Mr. A. Pelly Fry also of Messrs. Forbes & Walker, Mr. M. P. Saunders and Messrs. Whittall & Co., Mr. H. W. T. Sherwood and to Messrs. Harrisons & Crosfield, Ltd., Mr. C. J. Speer of the Colombo Commercial Co. very kindly undertook to help us with tasting of rolling experiment teas and we are indebted to him and to Mr. R. C. Kerr for the help they have given.

Mr. F. J. Whitehead has for another year given us the benefit of his advice and criticism.

J. LAMB,
Biochemist.

REPORT

OF

THE SMALL-HOLDINGS OFFICER,

BADDEGAMA, FOR 1941.

Kottawa Village Committee.—Advisory work was concentrated in this area which comprises the Kottawa and Walawe Palatas in the Talpe Pattu, Galle District.

As anticipated in my 1940 report, the area was found to be extremely backward agriculturally. Abandoned tea holdings, chenas, and paddy fields were a common sight.

There was a demand for the small-holders' green leaf, and tea coupons were fetching high prices. Both these factors tended to undermine any incentive the small-holder may have had for developing his holding.

The temptation to prospect for plumbago was irresistible. Prices paid for rubber were attractive, and small-holders generally were more inclined to attend to their rubber holdings.

In these circumstances, advisory work among tea small-holders, during the year, proved extremely difficult.

Small-Holdings Competition.—After the preliminary visits a competition was initiated in the two Palatas. 93 small-holders could have entered the competition. Of these 36 sent in entries. 24 of the entrants who showed signs of activity were taken round the 1940 working area, and demonstrations and instruction classes held in the prize-winning holdings of that year. 18 of these succeeded in reaching competition standard. These 18 and 4 others who managed to come up well, were put up for the final judging in December, which was carried out by Dr. T. Eden, the Agricultural Chemist of the Institute.

Final Judging.—A tendency to leave things entirely to the labourers they engaged was observed among some of the competitors. The labourers in turn made capital of the situation and skipped over field works.

Carefully carried out demonstrations were deliberately ignored, as they entailed more work, and the mischief done was only discovered when

the Small-Holdings Officer came along on his rounds. Redoing of these field works was insisted upon, and the owners had to pay for their lack of supervision by expenditure incurred twice over. Where, however, there was strict supervision of the labourers by the owner a high standard of work was obtained.

A good augury for the future was the entry into the competition this year of a korale mudaliyar, a proctor, a town aratchie, a resthouse aratchie, two village committee members, a president of a co-operative society. All of them excepting one of the village committee members succeeded in entering the finals.

Floods and malaria and dysentery epidemics interfered considerably with the progress in the competition holdings.

In some holdings the progressive works carried out got washed off by the floods. But the competitors concerned showed a good spirit in going to it again.

Koragode village sent in eleven entries. Of these ten reached the finals and carried off four of the prizes. This significant development was the sequel to the suspension of coupons in the case of a tea small-holder who had allowed his holdings to become a miniature forest. Koragode could also claim another distinction. The first female small-holder to win a prize in the Southern Province Tea Small-holdings Competitions hailed from there.

Prize-Giving.—The prize-giving was held on 19-12-41 in the Kottawa Government School. The meeting was presided over by Mr. T. B. Panabokke, First Adigar, and Chairman of the Board of Control of the Institute, who also gave away the prizes. Panabokke Kumarihamy also graced the occasion with her presence.

The importance the Institute attaches to the work carried out among small-holders was clearly shown by the presence of the Chairman of the Board, and one of the senior staff of the Institute.

Considering the apathy prevailing among the small-holders of this area, the attendance at the meeting was satisfactory. In addition to small-holders who did not compete, 21 out of the 22 finalists attended with their wives. The keenness displayed by the 1939 and 1940 prize winners in coming long distances to be present on the occasion is worthy of mention.

Mr. S. Abeywickreme M.S.C., Udugama, made a strong appeal to the small-holders present, to make full use of the Institute's advice. Mr. Abeywickreme's keen interest in the work carried out among small-holders, and his hearty co-operation are greatly appreciated.

Mr. H. W. Amarasuriya, M.S.C., Galle: Mr. V. E. de Saram, Mudaliyar of Gangabodde Pattu: and Mr. H. R. Colquhoun, J.P., U.P.M., Nakiadeniya, also honoured the occasion with their presence.

To all those who supported the Institute's activities by so kindly attending the meeting, I tender my sincere thanks.

Prize-Winners.—There was a tie for the 3rd prize this year, and it became necessary to award an additional 3rd prize, of Rs. 10. The prize-winners were as follows:—

1st Prize.	Rs. 25.00	A. V. Francis Dias	Small-Holding	No.	SK. 3701
2nd „	„ 15.00	J. Chelis Appuhamy	„	„	„ SK. 306
3rd „	„ 10.00	K. G. Gunendra	„	„	„ SK. 3698
3rd „	„ 10.00	I. H. M. Piyadasa	„	„	„ SK. 440
Commended		Proctor M. S. Gooneratne	„	„	„ SK. 3143

Gift of Tea.—A gift of tea was made by Iddamaldeniya estate, Kottawa. These were issued to 21 of the competitors who succeeded in entering the finals.

The interest evinced by the proprietor of this estate, and his superintendent, in the Institute's activities deserves mention.

Advisory Visits.—Visits to small-holdings and small estates, during the year, were as follows:—

First visits to small-holdings	...	166
Revisits	...	1,389
First visits and revisits to small estates		97
Total visits	...	1,652

On these visits, 347 demonstrations pertaining to all aspects of advisory work were carried out.

Tea.—The jat in most holdings was rather mixed. In some of the prize winning holdings the bushes throughout were looking vigorous and in fine heart.

Pruning.—As in the 1939 and 1940 working areas, clean-pruning was in vogue.

Lung-pruning was introduced into the area and carried out successfully on Sk. 3143, 6 acres and Sk. 3701, two of the prize-winners.

The absence of casualties after pruning this year was quite a surprise to both these owners.

In some of the competition holdings, in spite of carefully carried out lung-pruning demonstrations, the hired pruners had been allowed to do a clean-prune. In others, a cut-across was encouraged. Sk. 306, Sk. 3698, and Sk. 440 were three holdings where this light pruning was carried out as advised. A good many of the competitors took the trouble to tar the larger pruning cuts.

20 small-holders who were found to be doing their own pruning, had the lung-pruning method demonstrated to them. It is hoped that they will encourage this method in their villages.

Plucking.—Generally, the small-holders' interest in his tea is governed by the vagaries of the green leaf market. Where there is no demand for his leaf, or when plucking is unremunerative, he has no compunction about abandoning his holding. When green leaf prices are remunerative he switches off to the other extreme — hurried and careless pruning, premature tipping, and hard plucking.

This practice was clearly demonstrated during the year. During the early part of it coupons fetched good prices and there was no demand for his green leaf. Holdings were then abandoned. Later in the year coupon prices fell and green leaf prices rose. Then there was a burst of activity, accompanied by reckless pruning, hurried and careless tipping and plucking for weight.

Competitors were encouraged to keep accurate records of their crop figures, supported by receipts obtained from factories to which they were giving their green leaf. They were also regularly kept informed of what they could expect for their green leaf.

Supplying.—Supplying was well in hand. On Sk. 3143 alone nearly two acres of supplying was carried out. Here large supply holes were cut and filled with top soil from the forest adjoining. Isolation of supplies was successfully carried out in Sk. 2845, with the "Biped" spade already referred to.

Tea Seed—A maund of seed costing Rs. 100 was obtained for small-holder No. Sk. 341. This same seed had cost Rs. 75 a maund in 1940. The small-holder concerned was one of the 1940 competition prize-winners.

Home Made Tea—Sk. 2006, one of the 1940 competitors, started to make tea at home during the year. Samples of the teas made were forwarded to the Institute, and reported upon favourably by the Biochemist.

The advice given by the Institute was conveyed to the small-holder, who, at the prize-giving this year, presented some of the tea to the Chairman and Dr. T. Eden.

Shade and Green Manure Trees.—Most of the competitors had albizzias and gliricidias, but their training and proper utilization was not understood by them. Instruction in this was one aspect of the advisory work carried out.

On Sk. 306, the 2nd prize-winner, the old sprawling gliricidias were all cut down, and the holding replanted with six foot cuttings.

Where further use could be made of the old albizzias and gliricidias, they were trained to proper shape and the wounds tarred. Ends of cuttings were also tarred.

Sk. 2999, one of the competitors, trained his old gliricidias extremely well, and applied Candarsan on the wounds.

Most of the competitors were able to get up a gliricidia boundary fence, in addition to planting cuttings on their holdings. In some holdings difficulty was experienced in the bringing up of gliricidias, owing to the depredations of deer and porcupine. While the former cleared even fences to get at the tender branches, the latter dug at the roots and prostrated the cuttings.

In some holdings *Croton lacciferus* and *Strychnos nux-vomica* were successfully established in addition to the green manures already mentioned.

Bush Green Manures.—A certain amount of success was obtained with *Crotalaria usaramoensis* in contour hedges.

A pest was observed in the *Clitoria cajanifolia* contour hedges established in SK. 2105. This pest was brought under control with a soap emulsion spray. The contour hedges are now thoroughly well established here and they are regularly cut for forking in or mulching.

Clitoria was also successfully established in Sk. 2845, the 1940 competition first prize-winner.

Sun-flower cuttings were partially successful in Sk. 2105 and Sk. 487.

Ground Covers.—*Indigofera endecaphylla* was successfully established in 21 of the competition holdings. In those holdings where it was tended carefully it is spreading.

Weeding.—15 of the competitors now use the eetie for weeding. The weeds are collected and used for composting.

Composting.—16 out of the 22 competitors who reached the finals are making compost on the 3 pit system. Much trouble was taken in the preparation of these pits. Edges of the pits were turfed and where necessary trenches were cut round them to keep off outside water and

invading roots. Most of the green stuff used for composting as well as cattle dung were bought from outside.

An iron standard is used for testing the compost during manufacture, and a record of dates of turning kept.

Some of the competitors who started composting rather early were able to apply it to their holdings during the forking.

On Sk. 306 the Indigofera was doing extremely well as a result of the application of compost.

Drains.—Extensive improvements were carried out in drains in the competition holdings, and erosion reduced to a minimum The competitors evinced keen interest in the various anti-erosion methods tried out. By the end of the year they had become thoroughly erosion-minded. The methods learnt should help them in their other agricultural activities.

Turf.—Turf was extensively used in the competition holdings, for protecting the banks of holdings adjoining paddy fields, spills of reverse slope drains, and spills of the lock and spill type drains, edges of walls of wide drains and leaders were also turfed. Sk. 306 regularly cut his turf and used it as a mulch on his holding. Sk. 2845 used it for composting. Paspalum grass was also successfully established in Sk. 2845.

Terracing.—Impressive work with stones was carried out in some of the competition holdings. Crescent shaped stone terraces were also built under root exposed tea bushes, and silt from drains put behind them to cover the roots. Sides and beds of leading drains, as well as spills of reverse slopes were in some cases revetted with stones. Sk. 306 built a stone terrace all round his holding, in an effort to prevent it from getting washed off by floods. In some holdings stones were also used as splash cushions. Where no stones were available, coconut husks, felled trees, and cut branches of other crops were used to prevent wash.

Cultivation.—19 out of the 22 finalists completed the forking of their holdings. 7 of them applied coconut poonac, 1 applied artificial manure, while 11 others applied compost and prunings or weathered straw and green manures.

In the majority of these holdings this was the first time a forking had been carried out.

Other Crops.—In a good many of the competition holdings, other crops that were found unproductive were cut down and the trunks used as described above.

Pests and Diseases.—Termites and Red Ants were common. Ant hills in the competition holdings were all demolished. Red Coffee Borer was observed in Sk. 2078. The owner was given advice about its control.

Estates.—Mr. W. Amerasinghe, the Chairman of the Wanduramba Village Committee and the Proprietor of Leo Group, as well as his estate staff have continued to give me their whole-hearted support. Their help has been unstinted and spontaneous. The support from Leo Group is most inspiring and is a real tower of strength. My sincere thanks go out to all on Leo Group.

Principal, Farm School.—Once again I have to thank the Principal and Manager of the Farm School, Peradeniya, for supplying the necessary green manure cuttings and seeds, free of cost. Their hearty co-operation is hereby acknowledged.

Co-operative Societies.—Close contact was maintained with the co-operative societies in the working areas. The following were addressed: Nathewela Co-operative Society; Karagode Co-operative Society; The Gangagodde Pattu Co-operative Banking Union Conference. An address was also given at the Annual Celebrations of the Mahalapitiya School. At these meetings strong support was given me by Mr. S. Abeywickreme, M.S.C., Udugama, and Mr. H. W. Amarasuriya, M.S.C., Galle. I thank them for their co-operation.

Chief Headmen.—The Mudaliyar of Talpe Pattu, and the Headmen of Walawe and Kottawa Palatas have given me strong support. The Vidane Aratchie of Kottawa Palata and the Village Headman of Talgampola and Kottawa have been particularly helpful. I thank them all. As in previous years, the Mudaliyar of Gangabodde Pattu, his Headmen and his Chief Clerk, have continued to give me their support. I thank them too.

Office.—26 small-holders visited the office and obtained necessary advice. During the year 201 letters were received and 594 sent out.

The War.—War Pictorials received from the Information Officer were distributed to small-holders. Contributions from salary to war funds were continued during the year. The V sign was carried to small-holdings in the form of V-shaped controls in storm drains which proved most effective.

Quarters.—No change.

With the close of 1941, intensive work in two Village Committee areas situated in two Chief Headmen's Divisions have been completed. By means of three Tea Small-Holdings Competitions interest has been roused among small-holders, and the foundation of progressive work laid. It is hoped that these competitions, like the pioneers of old, will go forward steadfastly, blazing a trail of good husbandry and hard and conscientious work.

F. D. TILLEKERATNE,
Small-Holdings Advisory Officer, S.P.

The Tea Research Institute of Ceylon.

BOARD OF CONTROL

(A) Representing the Planters' Association of Ceylon:—

(1) Mr. R. G. Coombe.

(2) Mr. James Forbes (on leave), Mr. G. K. Newton (acting).

(3) Mr. J. D. Hoare

(B) Representing the Ceylon Estates Proprietary Association:—

(4) Major J. W. Oldfield, C.M.G., O.B.E., M.C.

(5) Mr. I. L. Cameron (on leave) Mr. W. H. Gourlay (acting)

(6) Mr. J. C. Kelly

(C) Representing the Low-Country Products' Association:—

(7) Mr. W. P. H. Dias

(D) Representing the Small-Holders:—

(8) Mr. T. B. Panabokke, First Adigar (Chairman)

(E) Ex-Officio Members:—

(9) The Hon. the Financial Secretary

(10) The Director of Agriculture

(11) The Chairman, Planters' Association of Ceylon

(12) The Chairman, Ceylon Estates Proprietary Association

Secretary, Roland V. Norris, D.Sc., St. Coombs, Talawakelle.

PRINTERS:
H. W. CAVE & CO.,
COLOMBO.